CLS200, MLS300, and CAS200

Communications Specification

Watlow Anafaze

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Part No. 0600-1015-5100. Revision 3.0
November 2003

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Please Note: External safety devices must be used with this equipment.

Contents

Overview

This reference guide is designed to help applications software programmers with the following tasks:

- Interface to Watlow Anafaze MLS300, CLS200, MLS and CLS controllers, and the CAS200 and CAS scanners via serial communications.
- Modify the communications Anafaze protocol driver in the Watlow Anafaze Communications Driver Kit. (If you have the communications driver kit, you don't need to read this manual unless you want to modify the communications driver.)

In This Manual

The following sections are included in this guide:

Chapter 1: Anafaze/AB Protocol. Gives an overview and explanation of the Anafaze/Allen Bradley communications protocol.

Chapter 2: Modbus-RTU Protocol. Gives an overview and explanation of the Modbus-RTU communications protocol

Chapters 1 and 2: Data Table Summary. Provides standard controller data table maps for the parameters (one for each protocol).

Chapter 3: Parameters Description. Describes each parameter.

Appendix A: Communications driver.

Glossary: Explanation of commonly used terms and acronyms.

NOTE

This reference guide is not a tutorial. It does not explain how to use the controller; it is not a programming reference; it also does not explain PID control, alarms, linear scaling, or other topics that are explained in detail in the controller manuals. If you need additional information about a topic covered in this reference guide, consult the documentation included with your controller.

Chapter 1: ANAFAZE/AB Protocol

This section explains the ANAFAZE/Allen Bradley protocol used in Watlow Anafaze MLS, CLS, and CAS devices. These controllers operate on serial communications links (EIA/TIA-232 or EIA-TIA-485) at either 2400 or 9600 baud. They use 8 data bits, one or 2 stop bits, and no parity.

Protocol Syntax

The controllers use a half-duplex (master-slave) protocol to interface to high-level software. The host software is considered the "master" and the controller is considered the "slave." In other words, the software can request information from the controller or download information to the controller. The controller can only respond to communications transactions initiated by the host software. The controller cannot initiate communications.

The controller and host software communicate by sending and receiving information in a "packet" format. A packet consists of a sequence of bytes in a specific format; it can be as large as 256 bytes of data. (For more information about packets, see the Packet Format section later in this chapter.)

The numbers in the packet are sent in binary format. However, our examples show bytes in hexadecimal format.

Control Codes

Watlow Anafaze abbreviates control codes this way:

Code	Meaning	Decimal Value	Hex Value
DLE	**Escape code** Signals the start of the other control code character sequences.	16	10
STX	**Start Text** Begins a transmission.	02	02
ETX	**End Text** Ends a transmission.	03	03
ENQ	**Request Resend** Tells the controller to resend its last ACK or NAK. Host software sends this command, and the controller responds to it.	05	05

Code	Meaning	Decimal Value	Hex Value
ACK	**Acknowledged** Signals that a syntactically correct packet has been received.	06	06
NAK	**Not Acknowledged** Signals that an incorrect, invalid packet has been received.	21	15

Transaction Sequence

Here are the four steps in a transaction between the host software and the controller. The following example shows the transaction as an exchange of packets. The example also assumes that there are no communication errors in the exchange.

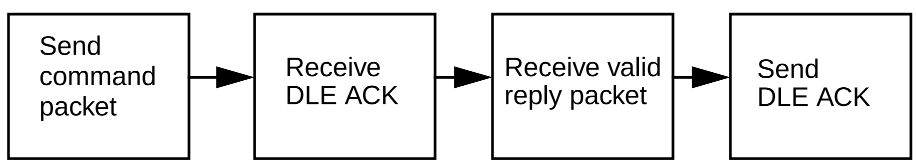
(1) The host software sends a packet that contains a read command or write command.

(2) The controller sends a DLE ACK to the host software.

(3) The host software receives a reply packet from the controller.

(4) The host software sends a DLE ACK.

The following flowchart shows a transaction with no error handling.

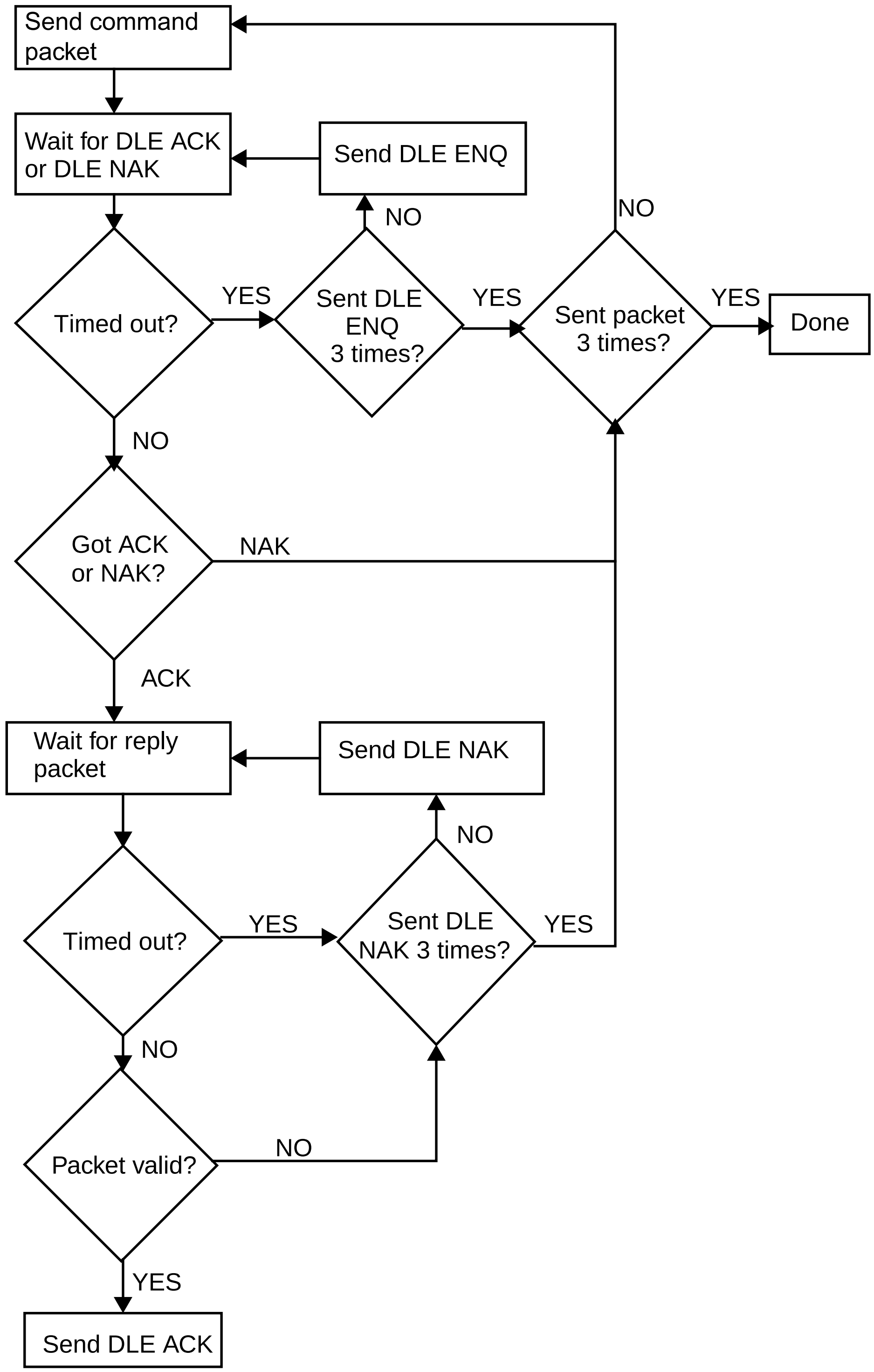


(*continued on next page*)

NOTE

Due to the difference between the processing speeds of the controller and PCs, it may be necessary to delay the computer's acknowledgement (ACK) in order for the controller to receive it. A delay of 200 ms should suffice.

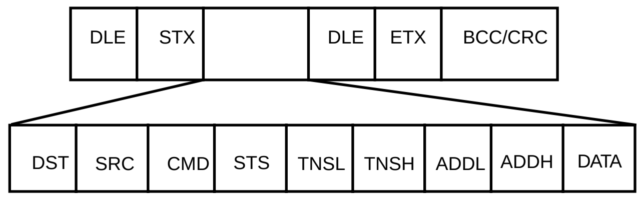
This flowchart shows one way for the host software to handle error checking. (If you are writing simple software, you don't necessarily need to use error handling routines as complete as these.)



Packet Format

Messages are transmitted in the form of packets. Command and reply packets specify the source and destination addresses, whether to read or write, the block of data to read or write, etc.

A packet contains a sequence of binary bytes formatted this way:



Sending Control Codes

To send a control code, send a DLE before the control code to distinguish it from data.

Sending a DLE as Data

When you send a byte with an x10, (a DLE), the controller and software interpret it as a command. Therefore, to send a DLE as data, send another DLE immediately before it (DLE DLE).

Codes in a Packet

This section describes the sequence of bytes in a packet, in the order the host software or controller sends them.

DLE STX

- The DLE STX byte signals the beginning of a transmission. Every packet of information starts with the control codes DLE STX.

DST

- The DST byte is the address of the destination device (usually a controller; the first Watlow Anafaze controller is at x08).

NOTE

When host software communicates with an MLS, a CLS, or a CAS in ANAFAZE or AB protocol, it does not send the controller's actual address. Since the protocol reserves device addresses 0 to 7, the host software sends the value (controller address + 7), instead of the actual device address.

SRC

- The SRC byte is the device address of the packet's source. The host software is usually designated address x00.

CMD

- The CMD byte indicates the command that the host software sends to the controller. The software sends a read (x01) or write (x08). When the controller replies, it returns the read or write command with the 7th bit set—in other words, it sends an x41 or x48.

STS (The Status Byte)

- The controller uses the status byte, or STS, to return general status and error flags to the host software. (The controller ignores the status byte in the host software's command packet.) The next table shows status byte values and definitions.
- An “x” in the status bytes below indicates that the associated nibble may contain additional information. In most cases, the status byte is composed of two independent nibbles. Each nibble is independent so that two codes can return at once. For example, status code F1 indicates that data has changed (Fx) and the controller is being updated through the front panel (x1).

Status in Hex	Description
00	The controller has nothing to report, or AB protocol is selected.
01	Access denied for editing. The controller is being updated through the front panel.
02	AIM Comm failure.
A0	A controller reset occurred.
Cx	The controller received a command that was not a block read or block write. (Command Error)
Dx	The block write command attempted to write beyond a particular parameter block boundary, or the host software attempted to access a data table block that does not exist. (Data Boundary Error)
Ex	The Alarm_Status variable has changed. The software should query the alarm status block to determine the particular alarm flag that changed.
Fx	The controller altered shared data, either internally (from the firmware) or externally (from the keyboard). The host software should read the Data Changed Register to determine which data has been altered and update its own run-time memory.

TNSL

- Least significant byte of the transaction number. This is the first half of a “message stamp.”
- The controller sends back the TNSL and TNSH exactly as it received them, so host software can use the TNSL and TNSH bytes to keep track of message packets.

TNSH

- Most significant byte of the transaction number. This is the second half of the “message stamp.”

ADDL

- The low byte of the beginning data table address of the block of data to read or write.

ADDH

- The high byte of the beginning data table address of the block of data to read or write.

DATA

- The new values to be set with a write command, or the requested data in a response to a read command.

DLE ETX

- Every packet of information must end with the codes DLE ETX. These codes signal the end of a transmission.

BCC or CRC

- Communications packets include a one- or two-byte error check at the end of the packet. There are two error check methods: Block Check Character (BCC), which requires 1 byte, and Cyclic Redundancy Check (CRC), which requires 2 bytes.

Error Checking

Watlow Anafaze recommends that you use the default error check method, BCC. It is easier to implement than CRC, and it is acceptable for most applications.

Select one error check method and configure both software and controller for that method, or they will be unable to communicate.

The error check methods work this way:

Block Check Character (BCC)

BCC checks the accuracy of each message packet transmission. It provides a medium level of security. The BCC is the 2’s complement of the 8-bit sum (modulo-256 arithmetic sum) of the data bytes between the DLE STX and the DLE ETX. (1’s complement +1)

- BCC does not detect transposed bytes in a packet.
- BCC cannot detect inserted or deleted 0 values in a packet.
- If you have sent an x10 as data (by sending DLE x10) only one of the DLE data bytes is included in the BCC’s sum (the DLE = x10 also).

For instance, the block read example shown in the examples section, adds x08 00 01 00 00 80 02 10. Note that the x10 representing DLE has been left out of the calculation. The sum should come to x9B.

1001 1011 = x9B
0110 0100 = 1's complement
+1 = 2's complement
____
0110 0101 = x65

Cyclic Redundancy Check (CRC)

CRC is a more secure error check method than BCC. It provides a very high level of data security. It can detect:

- All single-bit and double-bit errors.
- All errors of odd numbers of bits.
- All burst errors of 16 bits or less.
- 99.997% of 17-bit error bursts.
- 99.998% of 18-bit and larger error bursts.

The CRC is calculated using the value of the data bytes and the ETX byte. At the start of each message packet, the transmitter must clear a 16-bit CRC register.

When a byte is transmitted, it is exclusive-ORed with the right 8 bits of the CRC register and the result is transferred to the right 8 bits of the CRC register. The CRC register is then shifted right 8 times by inserting 0's on the left.

Each time a 1 is shifted out on the right, the CRC register is Exclusive-ORed with the constant value xA001. After the ETX value is transmitted, the CRC value is sent, least significant byte (LSB) first. **Below is a structured English procedure from AB Manual:**

```
data_byte = all application layer data, ETX
CLEAR CRC_REGISTER

FOR each data_byte
        GET data_byte
        XOR (data_byte, right eight bits of CRC_REGISTER)
        PLACE RESULT in right eight bits of CRC_REGISTER

        DO 8 times
                Shift bit right, shift in 0 at left
                IF bit shifted =1
                        XOR (CONSTANT, CRC_REGISTER)
                        PLACE RESULT in CRC_REGISTER
                END IF
        END DO
END FOR
TRANSMIT CRC_REGISTER as 2-byte CRC field
```

Examples

The host software sends two kinds of commands: block reads and block writes. This section shows examples of both commands.

NOTE

If you read data from a loop set to SKIP, the controller will send an empty packet for that loop.

This section does not show how to calculate the error check value included with every packet. For help calculating the error check value, see the section on BCC or CRC earlier in this chapter.

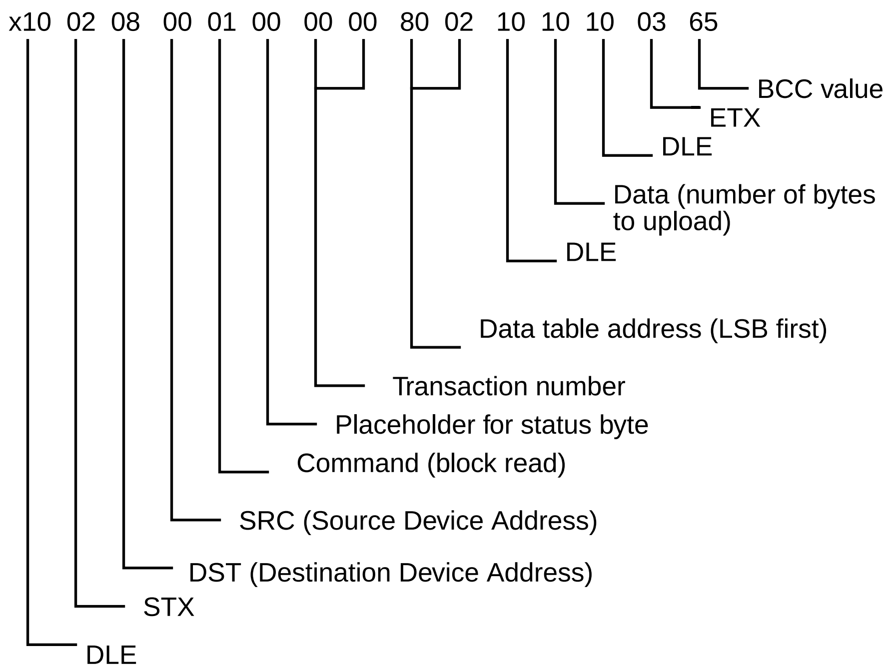
Block Read

This example shows the block read command the host software sends, the controller’s responses, and the software's acknowledgment.

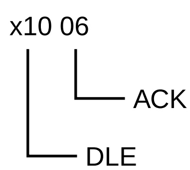
Situation: Read process variables for loops 1 to 8.

- 8 process variables 2 bytes each = 16 bytes from data table address x0280.
- Character values are represented in hex.
- The sender is device address 0.
- The destination is device address 8 (controller address 1).
- The software sends transaction number 00.

The next picture shows the read command.



The controller sends a DLE-ACK:



Then the controller sends its reply:

x10 02 00 08 41 00 00 00 (DATA) 10 03 C3

- BCC value
- ETX
- DLE
- Data (see below)
- Transaction number
- Status (00 = nothing to report)
- Command
- Source Device Address (controller address + 7)
- Destination Device Address
- STX
- DLE

DATA:

xE2 01 09 02 E4 01 09 02 F1 01 DF 01 28 3C E4 01

Data, transmitted LSB first. Assuming precision for loops is –1:
Loop 1 PV = x01E2 = 482, displayed as 48
Loop 2 PV = x0209 = 521, displayed as 52, etc.

Then the host software sends a DLE-ACK:

x10 06

- ACK
- DLE

Block Write

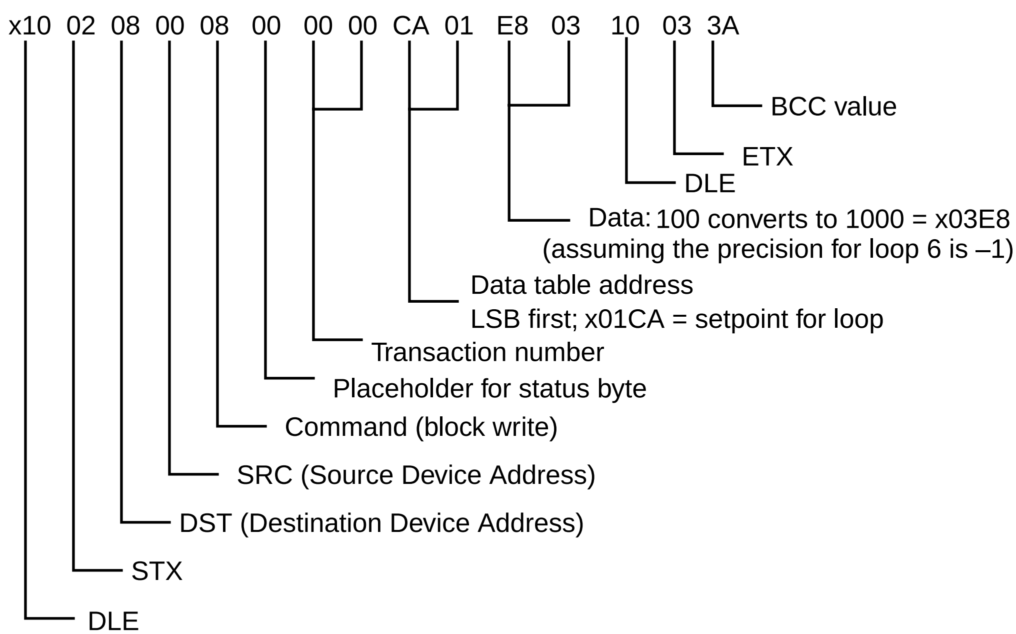
This section describes the block write command.

This example shows the block write command the master sends, the controller's responses, and the master's acknowledgment:

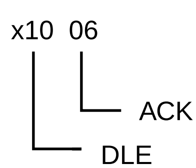
Situation: Write setpoint of 100 to loop 6.

- 1 setpoint 2 bytes per setpoint = 2 bytes to address x01CA (x01C0 + xA, a 10-byte offset).
- Character values are represented in hexadecimal.
- The sender is device address 0.
- The destination is device address 8 (controller address 1).
- The software sends transaction number 00.

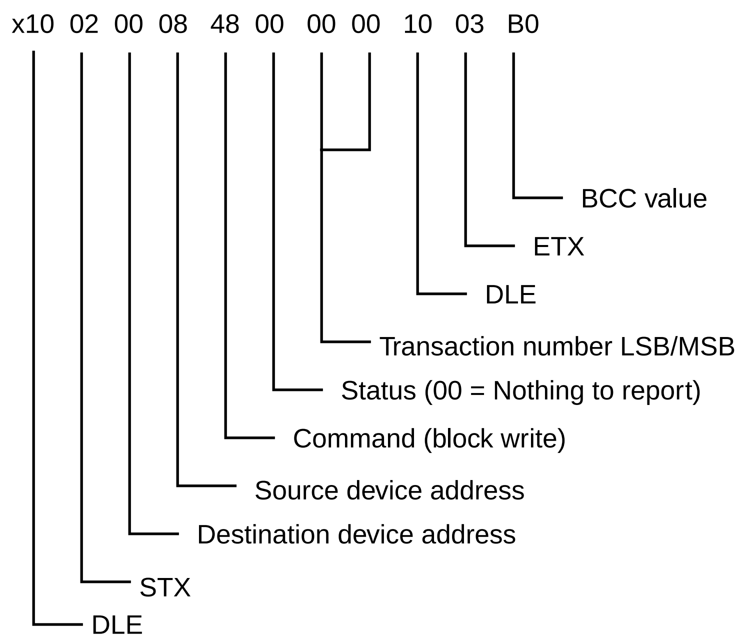
Here's a picture of the write command:



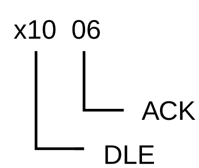
The controller sends a DLE-ACK:



Here's a picture of the controller's reply:



Then the host software sends a DLE-ACK:



Message Data

Some messages contain data. What the data is and how much depends on the command used and the purpose of the message.

Data for a Read Command

For a block read command, the data block consists of one byte that indicates the number of bytes to read (up to 244 bytes of data). The controller sends back a packet with a data block that contains the requested bytes.

Data for a Write Command

For a block write command, the block contains the bytes to write (up to 242 bytes of data). The controller sends back a message packet without data.

Two-Byte Data Types

For two-byte data types, like process variable and setpoint, the controller or host software sends the data in two-byte pairs with the least significant byte first.

Figuring Block Size

In order to read parameter values, you must know how many bytes to request. Parameter values are stored contiguously such that the setpoints for all the loops are stored together and in loop number order. For example, to read the deviation alarm deadband value for loops one to five, you would read five bytes starting at x05A0. Some parameters, such as setpoint, require two bytes of memory to store. So, for example, if you want to read the setpoint for four loops, you must read eight bytes.

Figure total block size in bytes for most loop parameters this way (do not forget the pulse loop):

(Data Size) * (Number of Loops)

Some parameters have values for both heat and cool. Figure block size for such a parameter this way:

2 * (Data Size) * (Number of Loops)

One exception is the units for each loop. Figure the data size for the units this way:

3 * (Number of Loops)

Parameters that are not loop parameters (like system status, digital inputs, or digital outputs) have specific data sizes. These data sizes are listed in the data table in the next section.

Anafaze/AB Data Table Summary

Each address holds one byte of data. Each parameter value requires one or two addresses to store depending on the type of data. The table below indicates the number of bytes for each data type. The data type for each parameter is indicated in the tables on the following pages.

Data Type and Symbol	Data Size
Unsigned char (UC)	1 byte
Signed char (SC)	1 byte
Unsigned int (UI)	2 bytes
Signed int (SI)	2 bytes

Because each loop is individually configurable, the number of instances of many parameters depends on the number of loops in the controller. Therefore, the number of bytes for these parameters is listed in the tables on the following pages in terms of the number of loops in the controller.

The storage requirements for some parameters depend on the number of digital inputs or digital outputs in the controller (MAX_DIGIN_BYTES and MAX_DIGOUT_BYTES). The storage of ramp-soak profile parameters depend on the number of profiles (MAX_RSP), the number of segments per profile (MAX_SEG), the number of triggers per segment (MAX_TRIG) and the number of events per segment (MAX_EVENT).

The table below shows the values for each of these factors. Use them to calculate the number of bytes for each parameter.

MAX_CH: 4CLS/CLS204 (4 loops + 1 pulse loop) 8CLS/CLS208 (8 loops + 1 pulse loop) 16CLS/CLS216/CAS200 (16 loops + 1 pulse loop) 16MLS/MLS316 (16 loops + 1 pulse loop) 32MLS/MLS332 (32 loops + 1 pulse loop)	 5 9 17 17 33
MAX_DIGIN_BYTES	1
MAX_DIGOUT_BYTES	8
MAX_RSP	17
MAX_SEG	20
MAX_TRIG	2
MAX_EVENT	4

Ordering of Heat and Cool Channel Parameters

For parameters that have both heat and cool settings the heat values are stored in the first registers and the cool values are stored in the registers starting at the listed address plus MAX_CH.

NOTE

Data table parameters 46 to 60 and 100 are ramp-soak parameters. They are only used in controllers with the ramp-soak option. Parameters 81 to 95 are enhanced features and only available in controllers with the enhanced features option.

Ordering of Ramp-Soak Profile Parameters

Ramp-soak profile parameters are ordered first by profile, then by segment where applicable. So, for example, the first eight bytes of the Ready Events parameter are the ready segment event states for the first profile (profile A) and the next eight bytes are for profile B and so on. In the case of the segment triggers, the first byte contains the first trigger setting for the first segment of profile A, the second byte contains the settings for the second trigger for the first segment of profile A, the third byte contains the settings for the first trigger for the second segment of profile A and so on.

Anafaze/AB Protocol Data Table

Number	Description	Address in Hex	Type	Number of Bytes
0	Proportional Band/Gain	0020	UC	MAX_CH * 2
1	Derivative Term	0060	UC	MAX_CH * 2
2	Integral Term	00A0	UI	MAX_CH * 4
3	Input Type	0120	UC	MAX_CH
4	Output Type	0180	UC	MAX_CH * 2
5	Setpoint	01C0	SI	MAX_CH * 2
6	Process Variable	0280	SI	MAX_CH * 2
7	Output Filter	0340	UC	MAX_CH * 2
8	Output Value	0380	UI	MAX_CH * 4
9	High Process Alarm Setpoint	0400	SI	MAX_CH * 2
10	Low Process Alarm Setpoint	04C0	SI	MAX_CH * 2
11	Deviation Alarm Band Value	05A0	UC	MAX_CH
12	Alarm Deadband	0600	UC	MAX_CH
13	Alarm Status	0660	UI	MAX_CH * 2
14	Not used	06A0		128

Number	Description	Address in Hex	Type	Number of Bytes
15	Ambient Sensor Readings	0720	SI	2
16	Pulse Sample Time	0730	UC	1
17	High Process Variable	0790	SI	MAX_CH * 2
18	Low Process Variable	0850	SI	MAX_CH * 2
19	Precision	0910	SC	MAX_CH
20	Cycle Time	09D0	UC	MAX_CH * 2
21	Zero Calibration	0A10	UI	2
22	Full Scale Calibration	0A16	UI	2
23	Not used	0A1C		4
24	Not used	0A20		64
25	Digital Inputs	0A60	UC	MAX_DIGIN_BYTES
26	Digital Outputs	0A70	UC	MAX_DIGOUT_BYTES
27	Reserved	0A80	UC	MAX_DIGOUT_BYTES
28	Override Digital Input	0AA0	UC	1
29	Override Polarity	0AC0	UC	1
30	System Status	0AC8	UC	4
31	System Command Register	0ACC	UC	1
32	Data Changed Register	0ACE	UC	1
33	Input Units	0AD0	UC	MAX_CH * 3
34	EPROM Version Code	0BF0	UC	12
35	Options Register	0BFC	UC	1
36	Process Power Digital Input	0C00	UC	1
37	High Reading	0C60	SI	MAX_CH * 2
38	Low Reading	0D20	SI	MAX_CH * 2
39	Heat/Cool Spread	0DE0	UC	MAX_CH
40	Startup Alarm Delay	0E20	UC	1
41	High Process Alarm Output Number	0E30	UC	MAX_CH
42	Low Process Alarm Output Number	0E90	UC	MAX_CH
43	High Deviation Alarm Output Number	0EF0	UC	MAX_CH
44	Low Deviation Alarm Output Number	0F50	UC	MAX_CH
45	Not used	0F60		MAX_CH
46	Channel Profile and Status	1000	UC	MAX_CH
47	Current Segment	1020	UC	MAX_CH
48	Segment Time Remaining	1040	UI	MAX_CH * 2
49	Current Cycle Number	1080	UI	MAX_CH * 2
50	Tolerance Alarm Time	10C0	UI	MAX_CH * 2
51	Last Segment	1100	UC	MAX_CH
52	Number Cycles	1120	UC	MAX_CH
53	Ready Setpoint	1140	SI	MAX_RSP * 2

Number	Description	Address in Hex	Type	Number of Bytes
54	Ready Event States	1180	UC	MAX_RSP * MAX_DIGOUT_BYTES
55	Segment Setpoint	1280	SI	MAX_RSP * 2 * MAX_SEG
56	Triggers and Trigger States	1780	UC	MAX_RSP* MAX_SEG* MAX_TRIG
57	Segment Events and Event States	1C80	UC	MAX_RSP * MAX_SEG * MAX_EVENT
58	Segment Time	2680	UI	MAX_RSP * 2 * MAX_SEG
59	Tolerance	2B80	SI	MAX_RSP * 2 * MAX_SEG
60	Ramp/Soak Flags	3080	UC	MAX_CH
61	Output Limit	3200	SI	MAX_CH * 4
62	Output Limit Time	3280	SI	MAX_CH * 4
63	Alarm_Control	3300	UI	MAX_CH * 2
64	Alarm_Acknowledge	33C0	UI	MAX_CH * 2
65	Alarm_Mask	3480	UI	MAX_CH * 2
66	Alarm_Enable	3540	UI	MAX_CH * 2
67	Output Override Percentage	3600	SI	MAX_CH * 4
68	AIM Failure Output	3690	UC	1
69	Output Linearity Curve	3700	UC	MAX_CH * 2
70	SDAC Mode	3740	UC	MAX_CH * 2
71	SDAC Low Value	3780	SI	MAX_CH * 4
72	SDAC High Value	3800	SI	MAX_CH * 4
73	Save Setup to Job	3880	UC	1
74	Input Filter	3890	UC	MAX_CH
75	Loop Alarm Delay	38D0	UI	MAX_CH * 2
76	Not used	3990		16
77	Loop Names (CLS/CLS200 and MLS/MLS300)	39A0	UI	MAX_CH * 2
78	T/C Failure Detection Flags (CLS/CLS200 and MLS/MLS300)	3A30	UC	MAX_CH
78	Channel Name (CAS/CAS200)	3994	UC	MAX_CH * 8
79	Restore PID Digital Input	4130	UC	MAX_CH
80	Manufacturing Test	4160	UI	1
81	PV Retransmit Primary Loop Number	4200	UC	MAX_CH * 2
82	PV Retransmit Maximum Input	4250	UI	MAX_CH * 4
83	PV Retransmit Maximum Output	42E0	UC	MAX_CH * 2

Number	Description	Address in Hex	Type	Number of Bytes
84	PV Retransmit Minimum Input	4330	UI	MAX_CH * 4
85	PV Retransmit Minimum Output	43C0	UC	MAX_CH * 2
86	Cascade Primary Loop Number	4410	UC	MAX_CH
87	Cacade Base Setpoint	4440	SI	MAX_CH * 2
88	Cacade Minimum Setpoint	4490	SI	MAX_CH * 2
89	Cascade Maximum Setpoint	44E0	SI	MAX_CH * 2
90	Cascade Heat/Cool Span	4530	UI	MAX_CH * 4
91	Ratio Control Master Loop Number	45C0	UC	MAX_CH
92	Ratio Control Minimum Setpoint	45F0	SI	MAX_CH * 2
93	Ratio Control Maximum Setpoint	4640	SI	MAX_CH * 2
94	Ratio Control Control Ratio	4690	UI	MAX_CH * 2
95	Ratio Control Setpoint Differential	46E0	SI	MAX_CH * 2
96	Loop Status	4730	UC	MAX_CH
97	Output Type/Disable	4760	UC	MAX_CH * 2
98	Output Reverse/Direct	47B0	UC	MAX_CH * 2
99	Controller Type	47F0	UC	1
100	Ramp/Soak Profile Number	4800	UC	MAX_CH
101	Controller Address	4830	UC	1
102	Baud Rate	4840	UC	1

Chapter 2: Modbus-RTU Protocol

Overview

Transactions on Modbus-RTU Networks

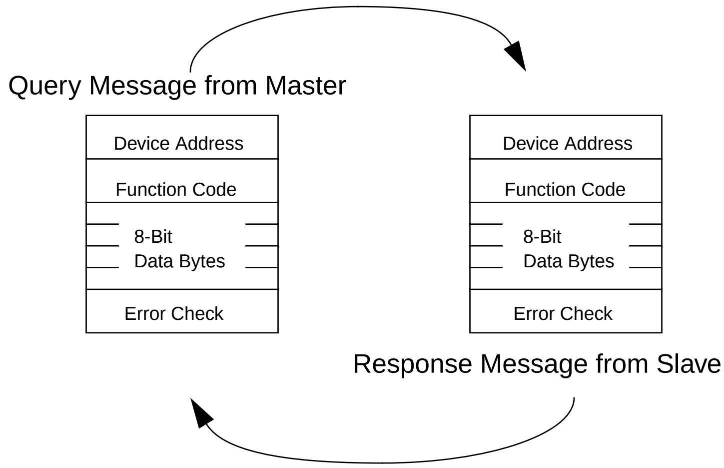
Standard Modbus-RTU ports use an EIA/TIA-232C- or EIA/TIA-485/422-compatible serial interface that defines connector pinouts, cabling, signal levels, transmission baud rates, and parity checking.

Controllers communicate using a master-slave technique, in which only one device (the master) can initiate transactions (called “queries”). The other devices (slaves) respond by supplying the requested data to the master, or by taking the action requested in the query. Typical master devices include host processors and programming panels.

The master can address individual slaves, or initiate a broadcast message to all slaves. Slaves return a message (called a “response”) to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.

The Modbus-RTU protocol establishes the format for the master’s query by placing into it the device (or broadcast) address, a function code defining the requested action, any data to be sent, and an error-checking field. The slave’s response message is also constructed using Modbus-RTU protocol. It contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error occurred in receipt of the message, or if the slave is unable to perform the requested action, the slave will construct an error message and send it as its response.

The Query-Response Cycle



The Query

The function code in the query tells the addressed slave device what kind of action to perform. The data bytes contain any additional information that the slave will need to perform the function. For example, function code 03 will query the slave to read holding registers and respond with their contents. The data field must contain the information telling the slave which register to start at and how many registers to read. The error check field provides a method for the slave to validate the integrity of the message contents.

The Response

If the slave makes a normal response, the function code in the response is an echo of the function code in the query. The data bytes contain the data collected by the slave, such as register values or status. If an error occurs, the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error. The error check field allows the master to confirm that the message contents are valid.

Serial Transmission

Each 8-bit byte in a message contains two 4-bit hexadecimal characters. This high character density allows better data throughput than ASCII for the same baud rate. Each message must be transmitted in a continuous stream.

Coding System

- 8-bit binary, hexadecimal 0 to 9, A to F
- 2 hexadecimal characters contained in each 8-bit field of the message

Bits per Byte

- 1 start bit

- 8 data bits, least significant bit sent first
- 2 stop bits
- No parity

Error Check Field

Cyclical Redundancy Check (CRC)

Message Framing

Messages start with a silent interval of at least 3.5 character times. This is most easily implemented as a multiple of character times at the baud rate that is being used on the network (shown as T1-T2-T3-T4 in the figure below). The first field then transmitted is the device address.

The allowable characters transmitted for all fields are hexadecimal 0 to 9, A to F. Networked devices monitor the network bus continuously, including during the silent intervals. When the first field (the address field) is received, each device decodes it to find out if it is the addressed device.

Following the last transmitted character, a similar interval of at least 3.5 character times marks the end of the message. A new message can begin after this interval.

Similarly, if a new message begins earlier than 3.5 character times following a previous message, the receiving device will consider it a continuation of the previous message. This will set an error, as the value in the final CRC field will not be valid for the combined messages. A typical message frame is shown below.

START	ADDRESS	FUNCTION	DATA	CRC CHECK	END
T1-T2-T3-T4	8 Bits	8 Bits	*n* * 8 Bits	16 Bits	T1-T2-T3-T4

Handling the Address Field

The address field of a message frame contains 8 bits. Valid slave device addresses are in the range of 0 to 247 decimal. The individual slave devices are assigned addresses in the range of 1 to 247 decimal. A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in this address field of the response to let the master know which slave is responding.

Handling the Function Field

The function code field of a message frame contains 8 bits. Valid codes are in the range of 1 to 255 decimal. Not all these codes are applicable to all controllers. Current codes are described in the *Function Codes* section.

When a message is sent from a master to a slave device, the function code field tells the slave what kind of action to perform. Examples are to read the On/Off states of a group of discrete coils or inputs; to read the data contents of a group of registers; or to read the diagnostic status of a slave.

When the slave responds to the master, it uses the function code field to indicate either a normal (error-free) response or that some kind of error occurred (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its most significant bit set to a logic 1.

For example, a message from the master to slave to read a group of holding registers would have the following function code:

0000 0011 x3

If the slave device takes the requested action without error, it returns the same code in its response. If an exception occurs, it returns:

1000 0011 x83

In addition to its modification of the function code for an exception response, the slave places a unique code into the data field of the response message. This tells the master what kind of error occurred, or the reason for the exception.

The master device's application program has the responsibility of handling exception responses. Typical processes are to post subsequent retries of the message, to try diagnostic messages to the slave, and to notify operators.

Contents of the Data Field

The data field is constructed using sets of two hexadecimal numbers, in the range of x00 to xFF.

The data field of messages sent from a master to slave devices contains additional information that the slave must use to take the action defined by the function code. This can include items like descrete and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field.

For example, if the master requests a slave to read a group of holding registers (function code 03), the data field specifies the starting register and how many registers are to be read.

If no error occurs, the data field of a response from a slave to a master contained the data requested. If an error occurs, the field contains an exception code that the master application can use to determine the next action to be taken.

The data field can be nonexistent (of zero length) in certain kinds of messages, where the function code alone specifies the action.

Contents of the Error Checking Field

The error checking field contains a 16-bit value implemented as two 8-bit bytes. The error check value is the result of a Cyclical Redundancy Check (CRC) calculation performed on the message contents.

The CRC field is appended to the message as the last field in the message. When this is done, the low-order byte of the field is appended first, followed by the high-order byte. The CRC high-order byte is the last byte to be sent in the message.

How Characters are Transmitted Serially

When messages are transmitted on standard Modbus-RTU serial networks, each character or byte is sent in this order (left to right):

Least Significant Bit (LSB).............Most Significant Bit (MSB)

The bit sequence is:

Start	1	2	3	4	5	6	7	8	Stop	Stop

CRC Error Checking

All messages include an error-checking field that is based on a Cyclical Redundancy Check (CRC) method. The CRC field checks the contents of the entire message. It is applied regardless of any parity check method used for the individual characters of the message.

The CRC field is two bytes, containing a 16-bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

The CRC is started by first preloading a 16-bit register to all 1's. Then a process begins of applying successive 8-bit bytes of the message to the current contents of the register. Only the 8 bits of data in each character are used for generating the CRC. Start and stop bits do not apply to the CRC.

During generation of the CRC, each 8-bit character is exclusive ORed with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive ORed with a preset, fixed xA001. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last shift, the next 8-bit byte is exclusive ORed with the register's current value, and the process repeats for eight more shifts as described above. The final contents of the register, after all the bytes of the message have been applied, is the CRC value.

Function Codes

The listing below shows the function codes supported by the CLS controllers. Codes are listed in decimal.

Code in Hex	Name
01	Read Coil Status
02	Read Input Status
03	Read Holding Registers
04	Read Input Registers
05	Force Single Coil
06	Preset Single Register
08	Diagnostics
0F	Force Multiple Coils
10	Preset Multiple Registers

x01 Read Coil Status

- Reads the On/Off status of discrete outputs (registers 00001 to 09999, the coils) in the slave. Broadcast is not supported.

x02 Read Input Status

- Reads the On/Off status of discrete inputs (registers 10001 to 19999) in the slave. Broadcast is not supported.

x03 Read Holding Registers

- Reads the binary contents of holding registers (registers 40001 to 49999) in the slave. Broadcast is not supported.

x04 Read Input Registers

- Reads the binary contents of input registers (registers 30001 to 39999) in the slave. Broadcast is not supported.

x05 Force Single Coil

- Forces a single coil (registers 00001 to 09999, the coils) to either On or Off. When broadcast, the function forces the same coil reference in all attached slaves.

NOTE

The function will override the controller's memory protect state and the coil's disable state. The forced state will remain valid until the controller's logic next solves the coil. The coil will remain forced if it is not programmed in the controller's logic.

x06 Preset Single Register

- Presets a value into a single holding register (registers 40001 to 49999). When broadcast, the function presets the same register reference in all attached slaves.

NOTE

The function will override the controller's memory protect state. The preset value will remain valid in the register until the controller's logic next solves the register contents. The register's value will remain if it is not programmed in the controller's logic.

x08 Diagnostics

- This function provides a series of tests for checking the communication system between the master and slave, or for checking various internal error conditions within the slave. Broadcast is not supported.
- The function uses a 2-byte subfunction code field in the query to define the type of test to be performed. The slave echoes both the function code and subfunction code in a normal response.
- Most of the diagnostic queries use a 2-byte data field to send diagnostic data or controller information to the slave. Some of the diagnostics cause data to be returned from the slave in a data field of a normal response.

Diagnostic Subfunctions

x00 Return Query Data

- The data passed in the query data field is to be returned (looped back) in the response. The entire response message should be identical to the query.

Subfunction	Data Field (Query)	Data Field (Response)
x00 00	Any	Echo Query Data

x01 Restart Communications Option

- The slave's peripheral port is to be initialized and restarted, and all of its communications event counters are to be cleared. If the port is currently in Listen Only Mode, no

response is returned. This function is the only one that brings the port out of Listen Only Mode. If the port is not currently in Listen Only Mode, a normal response is returned. This occurs before the restart is executed.

Subfunction	Data Field (Query)	Data Field (Response)
x00 01	x00 00	Echo Query Data
x00 01	xFF 00	Echo Query Data

x02 Return Diagnostic Register

- The contents of the slave's 16-bit diagnostic register are returned in the response.

Subfunction	Data Field (Query)	Data Field (Response)
x00 02	x00 00	Diagnostic Register Contents

x04 Force Listen Only Mode

- Forces the addressed slave to its Listen Only Mode for Modbus-RTU communications. This isolates it from the other devices on the network, allowing them to continue communicating without interruption from the addressed slave. No response is returned.
- When the slave enters its Listen Only Mode, all active communication controls are turned off. The ready watchdog timer is allowed to expire, locking the controls off. While in this mode, any Modbus-RTU messages addressed to the salve or broadcast are monitored, but no actions will be taken and no responses will be sent.
- The only function that will be processed after the mode is entered will be the Restart Communications Option function (function code 8, subfunction 1).

Subfunction	Data Field (Query)	Data Field (Response)
x00 04	x00 00	No Response Returned

x0A Clear Counters

- Clears all Communication Event counters. Counters are also cleared upon power-up.

Subfunction	Data Field (Query)	Data Field (Response)
x00 0A	x00 00	Echo Query Data

x0B Return Bus Message Count

- The response data field returns the quantity of messages that the slave has detected on the communications system since its last restart, clear counters operations, or power-up.

Subfunction	Data Field (Query)	Data Field (Response)
x00 0B	x00 00	Total Message Count

x0C Return Bus Communication Error Count

- The response data field returns the quantity of CRC errors encountered by the slave since its last restart, clear counters

operation, or power-up.

Subfunction	Data Field (Query)	Data Field (Response)
x00 0C	x00 00	CRC Error Count

x0D Return Bus Exception Error Count

- The response data field returns the quantity of Modbus-RTU exception responses returned by the slave since its last restart, clear counters operation, or power-up.

Subfunction	Data Field (Query)	Data Field (Response)
x00 0D	x00 00	Exception Error Count

x0E Return Slave Message Count

- The response data field returns the quantity of messages addressed to the slave, or broadcast, that the slave has processed since its last restart, clear counters operation, or power-up.

Subfunction	Data Field (Query)	Data Field (Response)
x00 0E	x00 00	Slave Message Count

x0F Return Slave No Response Count

- The response data field returns the quantity of messages addressed to the slave for which it returned a no response (neither a normal response nor an exception response), since its last restart, clear counters operation, or power-up.

Subfunction	Data Field (Query)	Data Field (Response)
x00 0F	x00 00	Slave No Response Count

x0F Force Multiple Coils

- Forces each coil (registers 00001 to 09999, the coils) in a sequence of coils to either ON or OFF. When broadcast, the function forces the same coil references in all attached slaves.

x10 Preset Multiple registers

- Presets values into the sequence of holding registers (registers 40001 to 49999). When broadcast, the function presets the same register references an all attached slaves.

NOTE

The function will override the controller's memory protect state. The preset values will remain valid in the registers until the controller's logic next solves the register contents. The register values will remain if they are not programmed in the controller's logic.

Writing Data

Watlow Anafaze controller memory is divided into approximately 100 parameters with unique control functions, such as temperature, set point, etc. Each parameter can have several Modbus-RTU addresses associated with it. When a Modbus-RTU host writes data to a controller parameter, the data sent may “command” controller firmware to perform specific functions. While host writes to multiple registers are permitted within a parameter, controller function hierarchies necessitate that only one parameter may be written at a time. Any data written past a parameter boundary is simply rejected.

Reading Data

The same parameter-based model is used for reading data from the controller’s Modbus-RTU interface. Modbus-RTU allows multiple register block reads for all types of registers. While Watlow Anafaze Modbus-RTU allows this type of read function, unexpected results may occur when reading registers that span across the boundaries of more than one parameter. A query from a Modbus-RTU host starts specific firmware processes that allow data to be formatted properly for the Modbus-RTU host. The sequence proceeds as follows:

(1) A query for data comes in from a Modbus-RTU host.

(2) The controller determines what parameter among the hundred or so is being queried.

(3) The data format from internal memory is converted for a Modbus-RTU interface.

  (a) Data for registers 40001 to 49999 and registers 30001 to 39999 are always two bytes in length. If the internal controller memory is in bit or byte size, the data is padded appropriately.

  (b) The byte order from internal memory is LSB to MSB (least significant byte to most significant byte. For example, the LSB first value for 550.0° would be x7C 15. The MSB first value would be x15 7C.) while the Modbus-RTU is MSB to LSB. Bytes are swapped as needed.

(4) Parameter data is sent to the Modbus-RTU interface.

When data from adjacent parameters is read and the parameters share the same data type (bit, byte or integer), the information is formatted correctly. However, if they do not share the same data type, host software could be written to pad and/or swap bytes as necessary.

Examples

Read Examples

The data read must be sequentially located. If you're reading a coil rather than a register, you must offset the address by the location of the bit you wish to read.

*Sample Packet for **Host** Transmission*

Example	Slave Address in Hex	Function in Hex	Start Address High in Hex	Start Address Low in Hex	Number of Points High in Hex	Number of Points Low in Hex	CRC High in Hex	CRC Low in Hex
1. Reading PV of loop 2 (1600), controller 1 (single-point read)	01	03	01	6C	00	01	45	EB
2. Reading loops 4 and 5 heat outputs, of controller 3 (multipoint read)	03	03	01	D1	00	02	94	2C
3. Reading digital input 4, controller 1 (input status read)	01	02	03	82	00	10	D9	AA

*Sample Packet for **Slave** Transmission*

Example	Slave Address in Hex	Function in Hex	Byte Count in Hex	Data in Hex	CRC High in Hex	CRC Low in Hex
1. Reading PV of loop 2 (1600), controller 1 (single-point read)	01	03	02	3E 80	84	1B
2. Reading loops 4 and 5 (50%, 60%) outputs (heat), of controller 3 (multipoint read)	03	03	04	3F DE 4C 4A	2D	41
3. Reading digital input 4, controller 1 (input status read)	01	02	02	08 00	BE	78

Write Examples

The data written is echoed back to the controller.

*Sample Packet for **Host** Transmission, a Single-Point Write*

Example	Slave Address in Hex	Function in Hex	Address High in Hex	Address Low in Hex	Data High in Hex	Data Low in Hex	CRC High in Hex	CRC Low in Hex
4. Writing loop 1 gain (20), controller 4 (single-point write)	04	06	00	00	00	14	89	90
5. Writing digital output 30 (on), controller 2 (single coil write)	02	05	03	A8	FF	00	0D	AD

*Sample Packet for **Slave** Transmission, a Single-Point Write*

Example	Slave Address in Hex	Function in Hex	Address High in Hex	Address Low in Hex	Data High in Hex	Data Low in Hex	CRC High in Hex	CRC Low in Hex
4. Writing loop 1 gain (20), controller 4 (single-point write)	04	06	00	00	00	14	89	90
5. Writing digital output 30 (on), controller 2 (single coil write)	02	05	03	A8	FF	00	OD	AD

*Sample Packet for **Host** Transmission, a Multipoint Write*

The data must be written to sequential locations.

Helpful hint: The string is longer for multiple write; checking the BYTE COUNT can help in determining if a command timeout is valid.

Example 6: Writing TI loops 3 (100) and 4 (150), controller 10.

Slave Address in Hex	Function in Hex	Address High in Hex	Address Low in Hex	Number of Registers High in Hex	Number of Registers Low in Hex	Byte Count in Hex	Data in Hex	CRC High in Hex	CRC Low in Hex
0A	10	00	86	00	02	04	00 64 00 96	9F	70

*Sample Packet for **Slave** Transmission, a multipoint write.*

Slave Address in Hex	Function in Hex	Address High in Hex	Address Low in Hex	Number of Registers High in Hex	Number of Registers Low in Hex	CRC High in Hex	CRC Low in Hex
0A	10	00	86	00	02	A1	5A

Modbus-RTU Data Table Summary

Each addressable register holds two bytes of data. Each parameter value requires only one register to store any of these types of data. The data type for each parameter is indicated in the tables on the following pages.

Data Type and Symbol	Data Size
Unsigned char (UC)	1 byte
Signed char (SC)	1 byte
Unsigned int (UI)	2 bytes
Signed int (SI)	2 bytes

Because each loop is individually configurable, the number of instances of many parameters depends on the number of loops in the controller. Therefore, the number of registers for these parameters is listed in the tables on the following pages in terms of the number of loops in the controller.

The storage requirements for some parameters depend on the number of digital inputs or digital outputs to the controller (MAX_DIGIN and MAX_DIGOUT). The storage of ramp-soak profile parameters depend on the number of profiles (MAX_RSP), the number of segments per profile (MAX_SEG), the number of triggers per segment (MAX_TRIG), and the number of events per segment (MAX_EVENT).

The table below shows the values for each of these factors. Use them to calculate the number of registers for each parameter.

MAX_CH:	
4CLS/CLS204 (4 loops + 1 pulse loop)	5
8CLS/CLS208 (8 loops + 1 pulse loop)	9
16CLS/CLS216/CAS200 (16 loops + 1 pulse loop)	17
16MLS/MLS316 (16 loops + 1 pulse loop)	17
32MLS/MLS332 (32 loops + 1 pulse loop	33
MAX_DIGIN	8
MAX_DIGOUT	35
MAX_RSP	17
MAX_SEG	20
MAX_TRIG	2
MAX_EVENT	4

NOTE

Data table parameters 46 to 60, 100 and 103 are ramp-soak parameters. They are only used in controllers with the ramp-soak option. Parameters 81 to 95 are enhanced features and are only available in controllers with the enhanced features option.

Ordering of Heat and Cool Channel Parameters

For parameters that have both heat and cool settings, the heat values are stored in the first registers and the cool values are stored in the registers starting at the listed address plus MAX_CH.

Ordering of Ramp-Soak Profile Parameters

Ramp-soak profile parameters are ordered first by profile, then by segment where applicable. So, for example, the first 35 registers of the Ready Events parameter are the ready segment event states for the first profile (profile A), the next 35 registers are for profile B, and so on. In the case of the segment triggers, the first register contains the first trigger setting for the first segment of profile A, the second register contains the settings for the second trigger for the first segment of profile A, the third register contains the settings for the first trigger for the second segment of profile A, and so on.

Relative and Absolute Modbus Addresses

In the tables on the following pages, absolute addresses are in decimal and relative addresses are in hexidecimal. Absolute addresses include the type of register. Refer to the absolute address to determine which function to use to read or write values (see the Function Codes on page 26).

Relative addresses indicate the register offset from the first register of the particular type. For example, the first register for the Derivative parameter is at 40067, which is offset 66 (x42) registers from the beginning of the holding registers at 40001.

Modbus-RTU Protocol Data Table

Number	Description	Absolute Address	Relative Address in Hex	Type	Number of Registers
0	Proportional Band/Gain	40001	0000	UC	MAX_CH * 2
1	Derivative Term	40067	0042	UC	MAX_CH * 2
2	Integral Term	40133	0084	UI	MAX_CH * 2
3	Input Type	40199	00C6	UC	MAX_CH
4	Output Type	40265	0108	UC	MAX_CH * 2
5	Setpoint	40331	014A	SI	MAX_CH
6	Process Variable	40364	016B	SI	MAX_CH
7	Output Filter	40397	018C	UC	MAX_CH * 2
8	Output Value	40463	01CE	UI	MAX_CH * 2
9	High Process Alarm Setpoint	40529	0210	SI	MAX_CH
10	Low Process Alarm Setpoint	40562	0231	SI	MAX_CH
11	Deviation Alarm Band Value	40595	0252	UC	MAX_CH
12	Alarm Deadband	40628	0273	UC	MAX_CH
13	Alarm_Status	40661	0294	UI	MAX_CH
14	Not used	40694	02B5		33
15	Ambient Sensor Readings	40727	02D6	SI	2
16	Pulse Sample Time	40729	02D8	UC	1
17	High Process Variable	40730	02D9	SI	MAX_CH
18	Low Process Variable	40763	02FA	SI	MAX_CH
19	Precision	40796	031B	SC	MAX_CH
20	Cycle Time	40829	033C	UC	MAX_CH
21	Zero Calibration	40895	037E	UI	2
22	Full Scale Calibration	40896	037F	UI	2
23	Not used	40897	0380		1
24	Not used	40898	0381		1
25	Digital Inputs	10899	0382	Bit	MAX_DIGIN
26	Digital Outputs	00907	038A	Bit	MAX_DIGOUT

Number	Description	Absolute Address	Relative Address in Hex	Type	Number of Registers
27	Not used	40942	03AD	UC	1
28	Override Digital Input	40943	03AE	UC	1
29	Override Polarity	40944	03AF	UC	1
30	System Status	40945	03B0	UC	4
31	System Command Register	40949	03B4	UC	1
32	Data Changed Register	40950	03B5	UC	1
33	Input Units	40951	03B6	UC	MAX_CH * 3
34	EPROM Version Code	41050	0419	UC	1
35	Options Register	41062	0425	UC	1
36	Process Power Digital Input	41063	0426	UC	1
37	High Reading	41064	0427	SI	MAX_CH
38	Low Reading	41097	0448	SI	MAX_CH
39	Heat/Cool Spread	41130	0469	UC	MAX_CH
40	Startup Alarm Delay	41163	048A	UC	1
41	High Process Alarm Output Number	41164	048B	UC	MAX_CH
42	Low Process Alarm Output Number	41197	04AC	UC	MAX_CH
43	High Deviation Alarm Output Number	41230	04CD	UC	MAX_CH
44	Low Deviation Alarm Output Number	41263	04EE	UC	MAX_CH
45	Not used	41296	050F		1
46	Channel Profile and Status	41297	0510	UC	MAX_CH
47	Current Segment	41330	0531	UC	MAX_CH
48	Segment Time Remaining	41363	0552	UI	MAX_CH
49	Current Cycle Number	41924	0783	UI	MAX_CH
50	Tolerance Alarm Time	41957	07A4	UI	MAX_CH
51	Last Segment	41990	07C5	UC	MAX_CH
52	Number of Cycles	42023	07E6	UC	MAX_CH
53	Ready Setpoint	42056	0807	SI	MAX_RSP
54	Ready Event States	42089	0828	UC	MAX_RSP * MAX_DIGOUT
55	Segment Setpoint	42174	087D	SI	MAX_RSP * MAX_SEG
56	Triggers and Trigger States	42834	0B11	UC	MAX_RSP * MAX_SEG * MAX_TRIG
57	Segment Events and Event States	44154	1039	UC	MAX_RSP * MAX_SEG * MAX_EVENT
58	Segment Time	46794	1A89	UI	MAX_RSP * MAX_SEG
59	Tolerance	47454	1D1D	SI	MAX_RSP * MAX_SEG
60	Ramp/Soak Flags	48114	1FB1	UC	MAX_CH

Number	Description	Absolute Address	Relative Address in Hex	Type	Number of Registers
61	Output Limit	48147	1FD2	SI	MAX_CH * 2
62	Output Limit Time	48213	2014	SI	MAX_CH * 2
63	Alarm_Control	48279	2056	UI	MAX_CH
64	Alarm_Acknowledge	48312	2077	UI	MAX_CH
65	Alarm_Mask	48345	2098	UI	MAX_CH
66	Alarm_Enable	48378	20B9	UI	MAX_CH
67	Output Override Percentage	48411	20DA	SI	MAX_CH * 2
68	AIM Fail Output	48477	211C	UC	1
69	Output Linearity Curve	48478	211D	UC	MAX_CH
70	SDAC Mode	48544	215F	UC	MAX_CH * 2
71	SDAC Low Value	48610	21A1	SI	MAX_CH * 2
72	SDAC High Value	48676	21E3	SI	MAX_CH * 2
73	Save Setup to Job	48742	2225	UC	1
74	Input Filter	48743	2226	UC	MAX_CH
75	Loop Alarm Delay	48776	2247	UI	MAX_CH
76	Not used	48809	2268		1
77	Loop Names (CLS/CLS200 and MLS/ MLS300)	48810	2269	UI	MAX_CH * 2
78	T/C Failure Detection Flags (CLS/CLS200 and MLS/ MLS300)	48876	22AB	UC	MAX_CH
78	Channel Name (CAS/CAS200)	48876	22AB	UC	MAX_CH * 8
79	Restore PID Digital Input	48909	22CC	UC	MAX_CH
80	Manufacturing Test (CLS/CLS200 and MLS/ MLS300)	48942	22ED	UI	1
80	Manufacturing Test (CAS/CAS200)	49014	2235	UI	1
81	PV Retransmit Primary Loop Number	48943	22EE	UC	MAX_CH * 2
82	PV Retransmit Maximum Input	49009	2330	UI	MAX_CH * 2
83	PV Retransmit Maximum Output	49075	2372	UC	MAX_CH * 2
84	PV Retransmit Minimum Input	49141	23B4	UI	MAX_CH * 2
85	PV Retransmit Minimum Output	49207	23F6	UC	MAX_CH * 2
86	Cascade Primary Loop Number	49273	2438	UC	MAX_CH

Number	Description	Absolute Address	Relative Address in Hex	Type	Number of Registers
87	Cacade Base Setpoint	49306	2459	SI	MAX_CH
88	Cascade Minimum Setpoint	49339	247A	SI	MAX_CH
89	Cascade Maximum Setpoint	49372	249B	SI	MAX_CH
90	Cascade Heat/Cool Span	49405	24BC	UI	MAX_CH * 2
91	Ratio Control Master Loop Number	49471	24FE	UC	MAX_CH
92	Ratio Control Minimum Setpoint	49504	251F	SI	MAX_CH
93	Ratio Control Maximum Setpoint	49537	2540	SI	MAX_CH
94	Ratio Control Control Ratio	49570	2561	UI	MAX_CH
95	Ratio Control Setpoint Differential	49603	2582	SI	MAX_CH
96	Loop Status	49636	25A3	UC	MAX_CH
97	Output Type/Disable	49669	25C4	UC	MAX_CH * 2
98	Output Reverse/Direct	49735	2506	UC	MAX_CH * 2
99	Controller Type	49801	2647	UC	1
100	Ramp/Soak Profile Number	49802	2649	UC	MAX_CH
101	Controller Address	49835	C2AB	UC	1
102	Baud Rate	49836	C2AC	UC	1
103	Ready Events (Modbus-RTU)	49837	266C	UC	MAX_RSP * MAX_DIGOUT

Chapter 3: Controller Parameter Descriptions

This section provides specific details for each data table parameter including data type, variable range, and default values where applicable.

The Controller Menus section on the next page shows all of the controller menus for MLS and CLS controllers. (Controller features and menus vary; not all of the menus shown here apply to each controller.) This is for reference only, to help you find applicable controller parameters to test your software.

WARNING

The controller's parameters are all read/write, and the controller does not check the content of data written to it. It is possible to write to any parameter, even though it may not be meaningful to do so.

Some of the controller's functions are not listed as data table parameters in this chapter. If a parameter is not listed in this chapter, one of the following situations applies:

- The parameter is set only in the controller's menus; it is not set in host software. For example, jobs are loaded through the controller's front panel only.
- The function may be a bit set in a byte in host software. For example, the panel lock feature does not have its own parameter; it is set in the System Command register.

Correlating Menu Items with Parameters

There is not a one-to-one correspondence between parameters found on the controller menus and the data table items. Some parameters that appear separately on the controller's display are combined when stored in the data table and when read or written via serial communications. The following tables lay out the correspondence between menu items and the data table.

In the following tables, “RS” in the Product(s) column indicates that the parameter is found in controllers equipped within the Ramp and Soak option firmware. Similarly, “EF” indicates that the parameter is found in controllers equipped with the Enhanced Features option.

Menu/Parameter	Product(s)	Parameter(s)
Single-Loop Display		
Setpoint	All Units	5
Process Variable	All Units	6
Heat Output Percent	Not CAS/CAS200	8
Cool Output Percent	Not CAS/CAS200	8
Control Mode	Not CAS/CAS200	4 or 96
Process/Deviation/Sensor Alarms	All Units	13, 64
System Alarms	All Units	13, 15
Assign R/S Profile	RS	46
Ramp Soak Profile	RS	100
Current Segment	RS	47
Time Remaining	RS	48
Cycle Number	RS	49
Set Mode	RS	46
Reset	RS	46
Global Menu		
Load Setup From Job	All Units	Front Panel Only
Job Save Number	All Units	73
Job Select Dig Inputs	All Units	23
Job Sel Dig Ins Active	All Units	24
Output Override Dig Input	Not CAS/CAS200	Front Panel Only
Override Dig In Active	Not CAS/CAS200	Front Panel Only
Startup Alarm Delay	All Units	40
Ramp/Soak Time Base	RS	31
Keyboard Lock Status	All Units	31
Power Up Output Status	Not CAS/CAS200	31
Process Power Digin	Not CAS/CAS200	Front Panel Only
Controller Address	Not CAS/CAS200	101
Communications Protocol	All Units	Front Panel Only
Communications Err Check	All Units	Front Panel Only
AC Line Freq	All Units	31
Dig Out Polarity on Alarm	All Units	31
Firmware Info	All Units	34, 35, 99
Input Menu		
Input Type	All Units	3
Loop Name	Not CAS/CAS200	77
Channel Name	CAS/CAS200 only	78

Menu/Parameter	Product(s)	Parameter(s)
Input Units	All Units	33
Input Reading Offset	All Units	17, 18
Reversed T/C Detect	Not CAS/CAS200	78
Input Pulse Sample Time	All Units	16
Display Format	All Units	19
Input Scaling Hi PV	All Units	17
Input Scaling Hi Rdg	All Units	37
Input Scaling Lo PV	All Units	18
Input Scaling Lo Rdg	All Units	38
Input Filter	All Units	74
Control Params Menu		
Heat Control PB	Not CAS/CAS200	0
Heat Control TI	Not CAS/CAS200	2
Heat Control TD	Not CAS/CAS200	1
Heat Control Filter	Not CAS/CAS200	7
Cool Control PB	Not CAS/CAS200	0
Cool Control TI	Not CAS/CAS200	2
Cool Control TD	Not CAS/CAS200	1
Cool Control Filter	Not CAS/CAS200	7
Spread	Not CAS/CAS200	39
Restore PID Digital Input	Not CAS/CAS200	79
Outputs Menu		
Heat Control Output	Not CAS/CAS200	4
Heat Output Type	Not CAS/CAS200	4, 97
Heat Output Cycle Time (TP)	Not CAS/CAS200	20
SDAC Mode	Not CAS/CAS200	70
SDAC Lo Value	Not CAS/CAS200	71
SDAC Hi Value	Not CAS/CAS200	72
Heat Output Action	Not CAS/CAS200	4, 98
Heat Output Limit	Not CAS/CAS200	61
Heat Output Limit Time	Not CAS/CAS200	62
Sensor Fail Ht Output	Not CAS/CAS200	67
Heat T/C Brk Out Avg	Not CAS/CAS200	78
Heat Output	Not CAS/CAS200	69
Cool Control Output	Not CAS/CAS200	4
Cool Output Type	Not CAS/CAS200	4, 97
Cool Output Cycle Time (TP)	Not CAS/CAS200	20
SDAC Mode	Not CAS/CAS200	70
SDAC Lo Value	Not CAS/CAS200	71
SDAC Hi Value	Not CAS/CAS200	72

Menu/Parameter	Product(s)	Parameter(s)
Cool Output Action	Not CAS/CAS200	4, 98
Cool Output Limit	Not CAS/CAS200	61
Cool Output Limit Time	Not CAS/CAS200	62
Sensor Fail Cl Output	Not CAS/CAS200	67
Cool T/C Brk Out Avg	Not CAS/CAS200	78
Cool Output	Not CAS/CAS200	69
Alarms Menu		
Hi Proc Alarm Setpt	All Units	9
Hi Proc Alarm Type	All Units	63, 65
Hi Proc Alarm Output	All Units	41
Dev Alarm Value	All Units	11
Hi Dev Alarm Type	All Units	63, 65
Hi Dev Alarm Output	All Units	43
Lo Dev Alarm Type	All Units	63, 65
Lo Dev Alarm Output	All Units	44
Lo Proc Alarm Setpt	All Units	10
Lo Proc Alarm Type	All Units	63, 65
Lo Proc Alarm Output	All Units	42
Alarm Deadband	All Units	12
Alarm Delay	All Units	40, 75
Manual I/O Test Menu		
Digital Inputs	All Units	25
Test Digital Output	All Units	26
Digital Output Number	All Units	26
Keypad Test	All Units	Front Panel only

Additional menus are found in controllers with Ramp and Soak and Enhanced Features options.

Menu/Parameter	Product(s)	Parameter(s)
Setup Loop PV Retransmit	EF and RS	
Heat Output Retrans PV	EF and RS	81
PV Retransmit Minimum Input	EF and RS	84
PV Retransmit Minimum Output	EF and RS	85
PV Retransmit Maximum Input	EF and RS	82
PV Retransmit Maximum Output	EF and RS	83
Cool Output Retrans PV	EF and RS	81
PV Retransmit Minimum Input	EF and RS	84
PV Retransmit Minimum Output	EF and RS	85
PV Retransmit Maximum Input	EF and RS	82
PV Retransmit Maximum Output	EF and RS	83
Setup Loop Cascade	EF	
Cascade Primary Loop Number	EF	86
Cascade Base Setpoint	EF	87
Cascade Minimum Setpoint	EF	88
Cascade Maximum Setpoint	EF	89
Cascade Heat Span	EF	90
Cascade Cool Span	EF	90
Setup Loop Ratio Control	EF	
Ratio Control Master Loop Number	EF	91
Ratio Control Minimum Setpoint	EF	92
Ratio Control Maximum Setpoint	EF	93
Ratio Control Ctrl Ratio	EF	94
Ratio Control SP Diff	EF	95
Setup Ramp/Soak Profile	RS	
Edit Ramp & Soak Profile	RS	Front Panel only
Copy Setup From Profile	RS	Front Panel only
Out-of-Tolrnce Alarm Time	RS	50
Ready Segment Setpoint	RS	53
Ready Segment Edit Events	RS	Front Panel only
Ready Event Output	RS	54
External Reset Input Number	RS	Front Panel only
Edit Segment Number	RS	Front Panel only
Segment ## Seg Time	RS	58
Segment ## Seg Setpt	RS	55
Segment ## Edit Seg Events	RS	Front Panel only
Seg ## Event # Output	RS	57
Seg ## Ev# DO## Active State	RS	57

Menu/Parameter	Product(s)	Parameter(s)
Segment ## Edit Seg Trggrs	RS	Front Panel only
Seg ## Trig # Input NR	RS	56
Seg ## Tr# DI## aCTIVE STATE	RS	56
SEG ## TR# DI## TRIG	RS	56
SEGMENT ## SEG TOLERANCE	RS	59
SEGMENT ## LAST SEGMENT	RS	51
REPEAT CYCLES	RS	52

Parameters (by number)

Proportional Band/Gain (0)

The MLS and CLS controllers let users modify the Proportional Band (PB), but they internally represent the PB as a Gain value.

- Range: 1 to 255.
- Heat/Cool: 35.
- Pulse: 20.
- Extruder Cool CH: 175.

Users edit the Proportional Band, but the controller uses a Gain value internally. This equation illustrates the relationship between the PB and Gain:

$$\text{Proportional Band} = \frac{\text{(High Range Value)} - \text{(Low Range Value)}}{\text{Gain}}$$

For example, on a J-type thermocouple the high range is 1400 and low range is –350, so a gain of 35 gives a PB of 50 degrees. (The input type ranges are listed in the Input Type section and in the *User's Guide* for your controller.)

Derivative Term (1)

This parameter contains the derivative term for PID output calculations. (The derivative term is also known as the TD or Rate.)

- Range: 0 to 255 seconds.
- EX PROM: 125.
- Pulse Loop: 0.
- All Others: 0.

Integral Term (2)

This parameter contains the integral term for PID output calculations. (The integral term is also known as the Reset or TI.)

- Range: 0 to 6000 seconds per repeat. (Setting the TI to 0 seconds turns off the integral action.)
- STD Heat: 180.
- STD Cool: 60.
- Extruder: 500.
- Pulse: 0.

Input Type (3)

This parameter specifies the input type.

- Range: 0 to 19 defined values.
- Default: 1 (J-type thermocouple).

The following input types are currently defined:

Decimal Number	Description	Hex Value	Range
0	Linear	00	–10 to 60 mV (scaleable)
1	J-type thermocouple	01	–350 to 1400°F –212 to 760°C
2	K-type thermocouple	02	–450 to 2500°F –268 to 1371°C
3	T-type thermocouple	03	–450 to 750°F –268 to 399°C
4	S-type thermocouple	04	0 to 3200°F –18 to 1760°C
5	R-type thermocouple	05	0 to 3210°F –18 to 1766°C
6	B-type thermocouple	06	150 to 3200°F 660 to 1760°C
7	Pulse Input (CLS, MLS, CAS)	07	0 to 2000 Hz
8	RTD1 (high resolution) (Not available in CLS216/16CLS and CAS200/ CAS)	08	–148 to 527°F –100 to 275°C
9	RTD2 (low resolution) (Not available in CLS216/16CLS and CAS200/ CAS)	09	–184 to 1544°F –120 to 840°C
10	Skip Channel	0A	N/A
11 to 13	Reserved for 8LS carbon potential	N/A	N/A
14	N/A	N/A	N/A
15	N/A	N/A	N/A
16	N/A	N/A	N/A
17	N/A	N/A	N/A
18	Nickel RTD (Available in some MLS controllers)	12	–940 to 572°F –700 to 300°C
19	Motor speed	13	–10 to 60 mV (scaleable)
20	E thermocouple	14	–328 to 1448°F –200 to 787°C

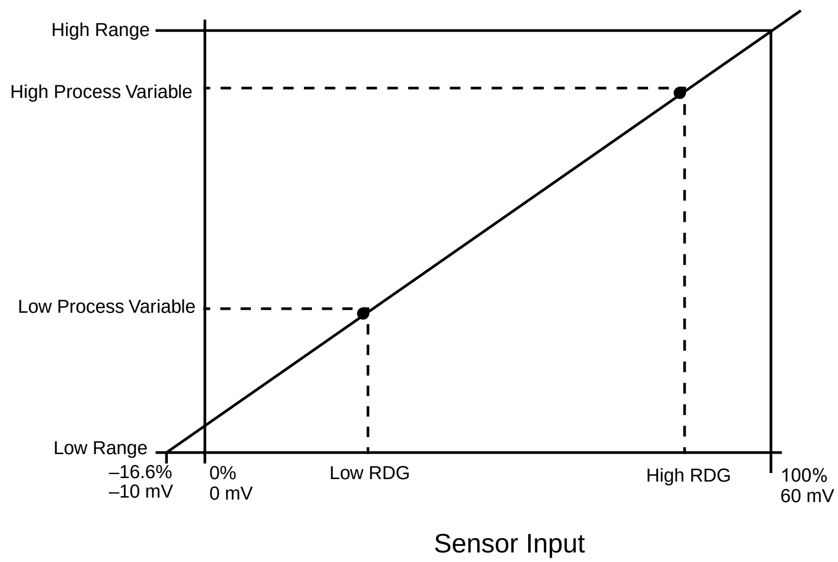
The input type determines the ranges for these other parameters:

- Process variable
- Setpoint

- Proportional band
- High process alarm
- Low process alarm
- Deviation band alarm
- Heat/cool spread
- Alarm deadband

Ranges for all input parameters are determined as follows:

- For thermocouple and RTD inputs, the high and low ranges are fixed at the values shown in the previous table.
- For pulse and linear inputs, the high and low ranges are determined by the values entered for input scaling, as shown in the graph below.



Output Type (4)

This parameter defines the output type of a given output pin.

- Default: Heat outputs default to manual control, enabled, reverse action, time proportioning. Cool outputs default to disabled, direct action, time proportioning.
- Range: A 1-byte value determined as shown in the tables below.

Bit	Bit set to 0	Bit set to 1
0 and 1	See below	
2	Loop is in automatic control	Loop is in manual control
3	Autotune mode off	Autotune mode on
4	Output disabled	Output enabled
5	Spare	Spare

Bit	Bit set to 0	Bit set to 1
6	Output not set to Serial DAC (see table below)	Output set to Serial DAC (see table below)
7	Output set to Reverse action	Output set to Direct action

Bits 0 and 1 work together to determine some of the output's characteristics:

Bit 6 Setting	Bit 1 Setting	Bit 0 Setting	Result
0	0	0	Time Proportioning
0	0	1	DZC
0	1	0	Analog (only 8LS)
0	1	1	On/Off
1	0	0	SDAC
1	0	1	3P DZC

NOTE

Bit 2 in the heat output-type byte determines the loop's control status (Automatic or Manual). The controller ignores Bit 2 in the cool output-type byte.

Setpoint (5)

This parameter contains the process setpoint, expressed in engineering units. (The setpoint is affected by the Precision parameter.)

- The setpoint's range depends on the loop's input type.
- The default setpoint for a J-type thermocouple is 250 (25°F).

Process Variable (6)

The process variable contains the compensated input measurement, expressed in engineering units. (This parameter is affected by the Precision parameter.)

- The process variable's range depends on the loop's input type (described in the Input Type section).

Output Filter (7)

The adjustable output filter dampens the control output response. (Setting the number of scans to 0 disables the filter.)

- Range: 0 to 255 scans.

- Default: 3 scans.

Output Value (8)

This parameter contains the output value, based on a full scale value of 32700 equals 100%. You can write to the output value at any time, but a write command is only meaningful for loops set to Manual control.

- Range: 0 to 32700 (0 to 100%).
- Default: 0.

High Process Alarm Setpoint (9)

The high process alarm setpoint is the absolute high process variable limit, expressed in engineering units. (This parameter is affected by the Precision parameter.)

- Range: –999 to 2500 (legal range determined by input type).
- Default: 10000 (1000°F) for a J-type thermocouple.

Low Process Alarm Setpoint (10)

The low process alarm setpoint is the absolute low process variable limit, expressed in engineering units. (This parameter is affected by the Precision parameter.)

- Range: –999 to 2500 (legal range determined by input type).
- Default: 0.

Deviation Alarm Band Value (11)

The deviation alarm band value indicates the amount of deviation from the setpoint before an alarm is issued. The amount of deviation is expressed in engineering units. (This parameter is affected by the Precision parameter.)

- Range: 0 to 255.
- Default: 5.

Alarm Deadband (12)

The alarm deadband prevents the alarm output from fluctuating rapidly when the input is near the alarm setpoint. (This parameter is affected by the Precision parameter.)

- Range: 0 to 255.
- Default: 2.

NOTE

Process alarms, deviation alarms, and failed sensor alarms are set individually for each loop. They are controlled by bit settings in a number of alarm variables.

This section uses the following expressions interchangeably:

Bit set to 1	True	Set
Bit set to 0	False	Cleared

Users can set loop alarms to warn them of high and low process variables and high and low deviation from the setpoint. Users can also set a loop alarm deadband value that prevents alarm "chattering" in process and deviation alarms. (There are also failed sensor alarms for some input types; users cannot configure the failed sensor alarms.)

All of these alarms are individually indicated. They can also be individually enabled, disabled, and acknowledged. The host software can observe and set process alarm and deviation alarm values.

NOTE

Alarms in MLS and CLS controllers depend on these five 16-bit variables, all unsigned integers: Alarm_Status, Alarm_Mask, Alarm_Enable, Alarm_Control, Alarm_Acknowledge.

Each of these variables is responsible for a different alarm behavior, attribute, or condition. Each of the controller's alarms has 1 bit in these variables; the table below shows the bit map for each variable. The bits are treated as 16 separate Boolean (TRUE/FALSE) variables.

Alarm_Status (13)

This parameter provides the current status of all the alarms for a loop, except for special ramp-soak alarms. When an alarm occurs, the controller sets the appropriate bit in Alarm_Status. When the alarm clears, the controller clears the bit for that alarm.

When using the Anafaze protocol, when an Alarm_Status bit has changed, and there are no higher–priority status codes to return, the controller will return an Ex (see the STS section in Chapter 1), in the high nibble of the next communications status byte it sends to the host software. The software should upload the Alarm_Status integers or words for all loops to determine which alarms have changed and in which loops.

Host software can read this parameter, but should not write to it.

NOTE

An alarm clears when its alarm condition is no longer present. If an alarm clears, and it has not already been acknowledged, it remains an unacknowledged alarm until the operator acknowledges it (by pressing the controller's Alarm Ack key or through software).

Do not use host software to alter the status of the Alarm_Status bits.

When Alarm_Status Trips

An alarm trips only if the Alarm_Mask bit, Alarm_Enable bit, and the alarm condition are all TRUE. For example, the high process alarm trips if the Alarm_Mask bit and Alarm_Enable bit are all true, and the process exceeds the high process alarm setpoint value.

When Alarm_Status Clears

An alarm clears when the condition that caused it clears, or when the Alarm_Mask bit is set to FALSE. For example, the high process alarm clears if the process goes below the high process alarm setpoint.

Bit	Alarm Name
0	Spare
1	Spare
2	Low deviation
3	High deviation
4	Low process
5	High process
6	T/C Reversed
7	T/C Short
8	T/C break (or open)
9	RTD open (not in 16CLS and CAS)
10	RTD short (not in 16CLS and CAS)
11	N/A
12	Ambient Warning (version 3.4 and later)
13	Ambient Cal Error

Bit	Alarm Name
14	Full Scale Cal Error
15	Offset Cal Error

Ambient Sensor Readings (15)

This parameter returns the value of the system ambient sensor in degrees Fahrenheit to a tenth of a degree. (The ambient sensor is used for ambient temperature compensation for thermocouples.) Most Watlow Anafaze controllers have only one ambient sensor; only the MLS-32 has two. However, the block size has been allocated to allow a maximum of six ambient sensors per system.

Pulse Sample Time (16)

This parameter is the sample period in seconds for the pulse counter input. (The pulse input is available for the CLS, MLS, and CAS only.)

- Range: 1 to 20 seconds.
- Default: 1 second.

High Process Variable (17)

This parameter is one of four points used to scale inputs, expressed in engineering units. (This parameter is affected by the Precision parameter.)

- Range: –9999 to 30000.
- Default: 14000 (1400F) for J-type thermocouple.

Low Process Variable (18)

This parameter is one of four points used to scale inputs, expressed in engineering units. (This parameter is affected by the Precision parameter.)

- Range: –9999 to 30000.
- Default: –3500 (–350°F) for J-type thermocouple.

NOTE

Whenever the Input Type or Units are changed, the High Process Variable and Low Process Variable parameters are set to the default values for the Input Type. see Input Type (3) on page 46 for a list of these values.

NOTE

Use the High Process Variable and Low Process Variable for an offset on all types of inputs. Add or Subtract the offset from both the High and Low Process Variables full scale valves. For example, for a J-type thermcouple, the full range is 14000 (1400°F) to –3500 (–350°F) with an offset of +5 degrees set the high Process Variable to 14050 and the low Process Variable to –3450, moving the full range scale up 5 degrees.

Precision (19)

The precision determines the number of decimal places in the associated parameters.

The value stored in this parameter affects several other parameters.

- Range: –1 to +4.
- Default: –1 for a J-type thermocouple.

The MLS, CLS and CAS do not store any floating-point values. Instead, they use the Precision parameter to simulate floating-point calculations for these other parameters:

- Process variable
- Setpoint
- Proportional band
- High process alarm
- Low process alarm
- Deviation band alarm
- Heat/cool spread
- Alarm deadband
- Ready setpoint
- Segment setpoint
- Tolerance value

When the controller sends values for these parameters to host software, it sends them as integers. To convert the numbers to a decimal, the host software must do the following:

(1) Take the number from the controller.

(2) Divide it by $10^{|p|}$ (where $|p|$ is the absolute value of the precision setting. So for example, if the precision is set to –1, divide values read via communications by 10, and if the precision is 2, divide by 100).

(3) If the original precision value (from the table below) was a negative number, round the number to the nearest integer. Otherwise, display the number.

Exception

For the deviation band alarm, heat/cool spread, and alarm deadband parameters, follow the procedure above, but if the precision value from the table is negative, display the raw number read from the controller.

Display Format Menu

When users edit the controller's Display Format menu for a linear input, they are really editing the precision for that input.

The next table shows the available precision values:

Precision Value	Display Format	Sample Raw Value Read via Communications	Scaled Display Value
–1	–999 to 3000	2556	257
0	–9999 to 30000	2556	2556
1	–999.9 to 3000.0	2556	255.6
2	–99.99 to 300.00	2556	25.56
3	–9.999 to 30.000	2556	2.556
4	–0.9999 to +3.0000	2556	0.2556

Cycle Time (20)

This parameter contains the time proportioning time base, expressed in seconds.

- Range: 0 to 255 seconds.
- Heat: 10.
- Cool: 3.

Zero Calibration (21)

This parameter returns the controller's zero calibration counts.

Full Scale Calibration (22)

This parameter returns the controller's full scale calibration counts

Digital Inputs (25)

This parameter returns the state of the controller's digital inputs. If the input is an open circuit (high) the corresponding value returns a 1. If the input is connected to common or low a 0 is returned.

The Anafaze/AB protocol returns all 8 bits in 1 byte. See the table below.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Input 8	Input 7	Input 6	input 5	Input 4	Input 3	Input 2	Input 1

The Modbus-RTU protocol stores the states of the inputs in eight individually addressable discrete input registers.

Digital Outputs (26)

This parameter contains the state of the controller's digital outputs. If the output is off (an open circuit), the value is 0. If the output is on, the value is 1. To turn on an output, set the corresponding bit to 1.

The Anafaze/AB protocol stores the states for up to eight outputs in 1 byte. So, a total of 5 bytes are required to store the states of the 35 digital outputs in a controller. See the table below to decode the bits.

- Default: 0 (off).

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25
Byte 4	Not used					35	34	33

The Modbus-RTU protocol stores the states of the outputs in 35 individually addressable coil registers.

Override Digital Input (28)

This parameter enables the output override feature and selects a digital input to trigger it. When the feature is enabled and the specified input is activated, the controller sets all loops to manual mode at the heat and cool outputs at the levels specified by the Output Override parameters.

- Range: 0 to 8 (Disabled = 0, Enabled = 1 to 8, indicating the selected digital input).
- Default: 0.

Override Polarity (29)

Specify whether a low or high signal activates the output override feature.

- Range: 0 or 1 (Low = 0, High = 1).
- Default: 0.

System Status (30)

The system status command consists of internal registers that flag hardware and software exceptions. The system status command takes 4 bytes. (None of the controllers use the last 2 bytes; they are reserved.)

Here is a bit map of the first 2 system status bytes. More than 1 bit can be set at a time.

Bit	0	1
0	Battery OK	Dead battery
1	Init Start OK	Bad Init Start Bit
2	AIM OK	AIM comm failure
3	No Ambient Error	Ambient Error
4	No Ambient Warning	Ambient Warning
5	Zero Calibration OK	Bad zero calibration
6	Full scale calibration value OK	Bad full scale calibration value
7	Reserved	
8	Alarms delay Off	Alarms delay On
9-13	Reserved	
14-15	See next table	

Here's a partial bit map of system status byte 2. The CLS and CAS use bits 14 and 15 only.

Bit 15 Setting	Bit 14 Setting	Result
0	0	Controller has 4 loops
0	1	Controller has 8 loops
1	0	Controller has 16 loops

System Command Register (31)

The System Command Register is a register of mode and configuration flags for the controller's processor.

- Default: 0.

Bit	0	1
0	Use default output data on startup.	Use memory data on startup.
1	Operator keys enabled.	Operator keys locked.
2	Unit set to 60 Hz.	Unit set to 50 Hz.
3	Ramp-soak time base in hours and minutes.	Ramp-soak time base in minutes and seconds.
4	Alarm digital outputs active Low.	Alarm digital outputs active High

Bit	0	1
5 *	Manufacturing Test	
6	Parameter reset bit	
7	Reserved	
* Warning: This may cause loss of data when used in normal operation. Use only when these tests are absolutely necessary.		

Data Changed Register (32)

The data changed register acts as a First-In-First-Out (FIFO) to point to parameters that have changed internally. The host software must query this register after receiving a “Data Changed” status flag to determine which data has changed. (For more information about “Data Changed” status flags, see the Status Byte section in Chapter 1.)

- Range: 0 to 255.

The general program flow goes like this:

(1) If there is anything in the controller’s internal Data Changed Stack, the controller returns a “Data Changed” status flag. (See the Status Byte section in Chapter 1 for an explanation of the “Data Changed” status flag.)

(2) The host receives a “Data Changed” flag in the communications packet.

(3) The host reads the Data Changed Register for the command number of the parameter that changed and then uploads that data block.

(4) The controller notes that the Data Changed Register has been read and waits for an Acknowledge from the host. When the Acknowledge has been received, the controller checks its own Data Changed Stack. If there are still data blocks that have been changed, but not uploaded, the controller puts the next command number in the Data Changed Register and continues to return a “Data Changed” status in communications packets. Otherwise, the Data Changed Register is cleared and no more Data Changed status flags are returned. (For more help on this topic, see the Status Byte section in Chapter 1.)

Input Units (33)

MLS, CLS, and CAS show the process variable expressed in engineering units. This parameter consists of three character strings that provide text representation of the engineering units for each loop. (The default input units for a J-type thermocouple—the default input type—are in °F.)

For thermocouple and RTD inputs, the input units are preset; the third character of the loop’s string indicates whether the reading is in degrees Celsius (if the second and third characters are “°C”), or in degrees Fahrenheit (if the second and third characters are “°F”).

For linear and pulse inputs, users can select three characters to display. This table shows valid entries:

Character	Decimal Value	Hex Value
(Space)	32	20
#	35	23
°	223	DF
%	37	25
/	47	2F
A to Z	65 to 90	41 to 5A
0 to 9	48 to 57	30 to 39

EPROM Version Code (34)

The firmware code for the EPROM version consists of 3 bytes. The first one contains the controller/unit model (MLS, CLS, and CAS). The second one contains the EPROM major revision, and the third one contains the EPROM minor revision.

The next table shows EPROM model codes. (Other codes are reserved for older controllers.)

Code	Model
9	MLS/MLS300
10	CLS/CL200
12	CAS/CAS200

WARNING

Watlow Anafaze recommends that you do not write to the EPROM-version parameter.

Options Register (35)

The options register is register of flags denoting firmware options in the controller. These options are currently defined:

Bit	0	1
0	Reserved	
1	Cascade option not present	Cascade-enhanced option
2	16-channel MLS	32-channel MLS
3	SmartWatch option not present	SmartWatch option

Bit	0	1
4	Extruder option not present	Extruder option
5	Ramp-soak not present	Ramp-soak
6	Math package not present	Math package
7	Reserved	

Process Power Digital Input (36)

Enable the thermocouple short detection feature by selecting a digital input.

- Range: 0 to 8 (Disabled = 0, Enabled = 1 to 8 indicating the selected digital input).
- Default: 0.

High Reading (37)

This parameter contains one of four points used to scale inputs. For thermocouple and RTD inputs, the high reading is expressed in tenths of a degree Celsius or Fahrenheit. For linear inputs, the high reading value is expressed in tenths (CLS) or hundredths (MLS) of a percent of full scale. For pulse inputs, the high reading value is expressed in Hertz.

- Range: –999 to 9999 (CLS), –9990 to 11000 (MLS).
- Default: 14000 (1400°F) for a J-type thermocouple.

Low Reading (38)

This parameter contains one of four points used to scale inputs. For thermocouple and RTD inputs, the low reading is expressed in tenths of a degree Celsius or Fahrenheit. For linear inputs, the low reading value is expressed in tenths (CLS) or hundredths (MLS) of a percent of full scale. For pulse inputs, the low reading value is expressed in Hertz.

- Range: –999 to 9999 (CLS), –9990 to 11000 (MLS).
- Default: –3500 (–350°F) for a J-type thermocouple.

NOTE

Note: Do not change High and Low Readings if the Input Type is NOT set to Linear or Pulse.

Heat/Cool Spread (39)

This parameter describes a deadband about the setpoint for heat/cool loops. The heat/cool spread is in units of the input variable. This parameter is affected by the Precision parameter.

- Range: 0 to 255.
- Default: 5.

Startup Alarm Delay (40)

This parameter designates a delay time for process and deviation alarms on power-up. The controller does not report process and deviation alarms for the specified number of minutes after the controller powers up.

The startup alarm delay is a global alarm parameter; it applies to all process and deviation alarms for every loop.

The startup alarm delay does not apply to failed-sensor alarms and AIM failure alarms.

- Range: 0 to 255 minutes.
- Default: 0.

High Process Alarm Output Number (41)

This parameter assigns the output number to which the high process alarm output is directed.

- Range: 0 to 34.
- Default: 0 (no high process alarm output).

Low Process Alarm Output Number (42)

This parameter assigns the output number to which the low process alarm output is directed.

- Range: 0 to 34.
- Default: 0 (no low process alarm output).

High Deviation Alarm Output Number (43)

This parameter assigns the output number to which the high deviation alarm output is directed.

- Range: 0 to 34.
- Default: 0 (no high deviation alarm output).

Low Deviation Alarm Output Number (44)

This parameter assigns the digital output number to which the low deviation alarm output is directed.

- Range: 0 to 34.

- Default: 0 (no low deviation alarm output).

Channel Profile and Status (46)

In this byte, bits 0 to 4 hold the ramp-soak profile number for the loop. Bits 5 to 7 hold the profile's status (Ready, Running, Hold, Trigger Wait, or Out of Tolerance).

- Range: See tables below.
- Default: 0.

Bits 0 to 4 hold the profile number and reference letter:

Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Profile Number	Ref. Letter
0	0	0	0	0	0	A
0	0	0	0	1	1	B
0	0	0	1	0	2	C
0	0	0	1	1	3	D
0	0	1	0	0	4	E
0	0	1	0	1	5	F
0	0	1	1	0	6	G
0	0	1	1	1	7	H
0	1	0	0	0	8	I
0	1	0	0	1	9	J
0	1	0	1	0	10	K
0	1	0	1	1	11	L
0	1	1	0	0	12	M
0	1	1	0	1	13	N
0	1	1	1	0	14	O
0	1	1	1	1	15	P
1	0	0	0	0	16	Q

Bits 5, 6, and 7 hold the profile status:

Bit 7	Bit 6	Bit 5	Status
0	0	0	Profile in Ready state “S”
0	0	1	Profile is running “R”
0	1	0	Profile is holding “H”
0	1	1	Profile in trigger wait state “W”
1	0	0	Profile out of tolerance “O”
1	1	1	No profile assigned

Current Segment (47)

This parameter returns the segment number that is currently executing. The controller's front panel displays (current segment parameter value +1).

If the user has not assigned a ramp-soak profile to the loop, this parameter is undefined.

If the loop is in Ready state, this parameter has a value of –1. In Ready state, the controller's front panel displays segment 0.

- Range: –1 to 19.
- Default: 0.

Segment Time Remaining (48)

If the time base is in minutes and seconds, this parameter holds the total remaining seconds, up to 999 minutes and 59 seconds. If the time base is in hours and minutes, this parameter holds the total remaining minutes, up to 999 hours, 59 minutes.

- Range: 0 to 59999.
- Default: 0.

Current Cycle Number (49)

This parameter returns the number of the current cycle. (Command 52, Number of Cycles, returns the total number of cycles to execute.)

- Range: 0 to 9999.
- Default: 0.

Tolerance Alarm Time (50)

The value of this parameter decrements once each time unit (each minute if the time base is set to hours and minutes, or each second if the time base is set to minutes and seconds), while the profile is out of tolerance. When a ramp-soak segment is out of tolerance for longer than the tolerance alarm time, the controller goes into tolerance alarm and the tolerance timer resets.

- Range: 0 to 59999.
- Default: 0.

Last Segment (51)

This parameter denotes the last segment in the profile.

- Range: 0 to 19.

- Default: 19.

Number of Cycles (52)

This parameter represents the total number of times to repeat the current profile. Users can set 1 to 99 repeat cycle profiles or they can set the profile to cycle continuously.

- Range: 0 (continuous), 1 to 99.
- Default: 1.

Ready Setpoint (53)

This parameter represents the ready segment's setpoint. The first segment begins ramping from the ready segment setpoint. When the profile ends, the process returns to this setpoint. (This value is affected by precision.)

- Range: Low Process Variable to high Process Variable. (–999 to 9999, legal value determined by input type.)
- Default: 0.

Special logic applies to determining the decimal placement for the Ready Setpoint when using the Anafaze/AB protocol. When a profile is assigned to a loop and the precision of the loop is greater than or equal to 0, the setpoint is divided by an additional factor of 10 when the precision is applied. When the profile is assigned to a loop with precision –1, the precision is applied to the setpoint as usual (see Precision (19) on page 53).

For example, if a profile with a Ready Setpoint of 1000 is assigned to a loop with its Input Type set to Linear and its Precision to 1, the resulting setpoint is 10. If the same profile were assigned to a loop with Input Type set to J-type thermocouple (precision set to –1), the setpoint would be 100.

For the Modbus-RTU protocol, the setpoint is scaled by the precision setting only.

Ready Event States (54)

This parameter describes the ready segment's output state for all outputs that are not used for control or for the SDAC clock. When the loop goes to the ready state, these outputs assume the state specified by this parameter.

- Range: 0 (off) or 1 (on).
- Default: 0 (off).

In the Anafaze/AB protocol, the states are stored as bits in 5 bytes. Each bit listed in the table below represents an output from 1 to 34.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25
Byte 4	Reserved						34	33

When accessed via the Modbus-RTU protocol, this parameter contains the ready segment event outputs for the first 10 profiles (A to J) only. The state of each is stored in its own register. For access to all the ready segment events, see parameter 103.

Segment Setpoint (55)

This parameter represents the setpoint the process variable will reach at the end of the segment. (This value is affected by precision)

- Range: Low Process Variable to High Process Variable. (–999 to 9999, legal value determined by input type.)
- Default: 0.

Special logic applies to determining the decimal placement for the Segment Setpoint when using the Anafaze/AB protocol. When a profile runs on a loop with a precision setting greater than or equal to 0, the setpoint is divided by an additional factor of 10 when the precision is applied. When the profile runs on a loop with precision –1, the precision is applied to the setpoint as usual (see Precision (19) on page 53).

For example, if a profile with a Segment Setpoint of 1000 runs on a loop with its Input Type set to Linear and its Precision to 1, the resulting setpoint is 10. If the same profile runs on a loop with Input Type set to J-type thermocouple (precision set to –1), the setpoint will be 100.

For the Modbus-RTU protocol, the setpoint is scaled by the precision setting only.

Triggers and Trigger States (56)

This byte holds the trigger input number, its active state, and its latch status. Triggers are saved in memory as indicated below.

Seg(1) Trig(1), Seg(1) Trig(2), Seg(2) Trig(1), Seg(2) Trig(2), etc.

- Range: 0 (no trigger), inputs 1 to 8.

- Default: 0 (no trigger assigned).

Bit	Bit set to 0	Bit set to 1
0 to 3	See below	
4 to 5	Reserved	
6	Unlatched trigger (trigger must remain true throughout the segment).	Latched trigger (trigger must be true at beginning of segment).
7	Active Off	Active On

Bits 0 to 3 determine the input number for the trigger:

Bit 3	Bit 2	Bit 1	Bit 0	Input Number
0	0	0	0	No trigger
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8

Segment Events and Event States (57)

This parameter holds the event output number and event state for a profile segment. Users can designate up to four events per segment; each event takes 1 byte. Events are saved in memory as indicated below.

Seg(1) Event(1), Seg(1) Event(2), Seg(1) Event(3), Seg(1) Event(4), Seg(2) Event(1), etc.

- Range: Outputs 1 to 34 (except outputs used for control or for the SDAC clock).
- Default: 0 (no event assigned).

Here's a bit map of the Event bytes:

Bit	Bit set to 0	Bit set to 1
0 to 5	Determines the output number for an event	
6	Reserved	
7	Event is active Off	Event is active On

Bits 0 to 5 determine the output number for an event:

Result	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
No events	0	0	0	0	0	0
Digital output 1 is an event	0	0	0	0	0	1
Digital output 2 is an event	0	0	0	0	1	0
Digital output 3 is an event	0	0	0	0	1	1
Digital outputs 4 to 33 are events	...	...	...	...	...	...
Digital output 34 is an event	1	0	0	0	1	0

Segment Time (58)

This parameter represents the duration of a segment, in the time units selected elsewhere (hours and minutes or minutes and seconds).

- Range: 0 to 59999.
- Default: 0.

Tolerance (59)

The tolerance parameter represents an user-defined allowable deviation from setpoint. If the process goes above a positive tolerance value or below a negative tolerance value, it is considered out of tolerance. See also Tolerance Alarm Time (50). This value is also affected by precision.

- Range: –99 to 99.
- Default: 0.

Ramp/Soak Flags (60)

This parameter is a byte register for each loop that has a ramp-soak profile assigned to it.

Here's a picture of this byte:

Bit	Bit set to 0	Bit set to 1
0	The segment is within the tolerance time period.	The segment is out of tolerance time period.
1 *	The segment does not require alarm acknowledgment. (Segment may be out of tolerance but is not in tolerance alarm.)	The user must acknowledge alarm. (Segment may be within tolerance.)
2	Reserved	

Bit	Bit set to 0	Bit set to 1
3	The profile is in trigger wait state	The profile is not in trigger wait state (remote hold)
4	Reserved	
5	Reserved	
6	Reserved	
7	Reserved	

* The controller toggles a bit in the data-changed register to notify high level software that the alarm status has changed.

Output Limit (61)

This parameter sets a limit on the output power percentage on either heat or cool outputs for any loop. The output limit works with the output limit time. While the limit is in effect, the output level will never exceed the specified limit.

- Range: 0 to 32700 (0 to 100%). Setting the limit to 100% (32700) disables it.
- Default: 32700 (100%), or disabled.

Output Limit Time (62)

This parameter describes the time span that the output limit is in effect.

- Range: 0 to 999 seconds. Setting the output limit time to 0 makes the output limit continuous; setting the output limit time from 1 to 999 seconds gives a range from 1 second to about 16 minutes.
- Default: 0 seconds (continuous output limit).

The output limit only affects loops in automatic control (AUTO). The time-out period is restarted whenever:

- A loop switches from manual to automatic control.
- The controller restarts.

Alarm_Control (63)

Setting a bit for an alarm in the Alarm_Control variable makes it a control alarm; clearing the bit makes it a standard alarm. This table explains the difference between standard alarms and control alarms.

Function	Description
Alarm	**When an alarm condition occurs:** The controller's display changes to the loop that's in alarm. An alarm message flashes on the display. The alarm's digital output activates. The global alarm output activates. The operator must press the Alarm Ack key to stop the flashing message and deactivate the global alarm before the controller will accept other input from the keypad.
Control	The alarm digital output activates on alarm and deactivates when the loop goes out of alarm. The global alarm output does not activate. Users do not have to acknowledge control alarms by pressing the alarm Ack key.

Alarm_Acknowledge (64)

When an alarm occurs and it is not a control alarm, the corresponding Alarm_Acknowledge bit is set. Clearing the bit acknowledges the alarm.

Alarm_Mask (65)

When users turn alarms on or off from the front panel keypad, they are really setting or clearing the Alarm_Mask variable. (When an alarm is turned on, its Alarm_Mask bit is set.)

Setting Alarm_Mask to TRUE does not trip or clear alarms; instead, it lets the alarm checking routine check for them. The controller does not set or clear Alarm_Mask by itself; users edit this bit through the front panel keypad or in host software.

See the table on page 51 for alarm bits.

Alarm_Enable (66)

The Alarm_Enable variable is like the Alarm_Mask variable, except it is a temporary mask. An alarm will not trip until its Alarm_Enable bit becomes true and the following conditions are also met:

- The alarm condition occurs.
- The Alarm_Mask bit is set.

This variable is currently used for deviation and process alarms. Process alarms are automatically enabled at startup. If a deviation alarm is turned on (its Alarm_Mask bit is set), then the alarm is disabled until the process variable comes within the deviation range:

(PV $\leq$ SP + DEV - DB)
to
(PV $\geq$ SP - DEV + DB)

If the process variable is already in this range, the Alarm_Enable bit is immediately set.

See the table on page 51 for alarm bits.

Output Override Percentage (67)

When a sensor failure occurs and the loop is in Automatic mode, the loop switches to Manual mode at the output override percentage. If users have configured an output override digital input, they set every loop to the output override percentage when they change the polarity of the output override's digital input to the active state.

- Range: 0 to 32700 (0 to 100%).
- Default: 0.

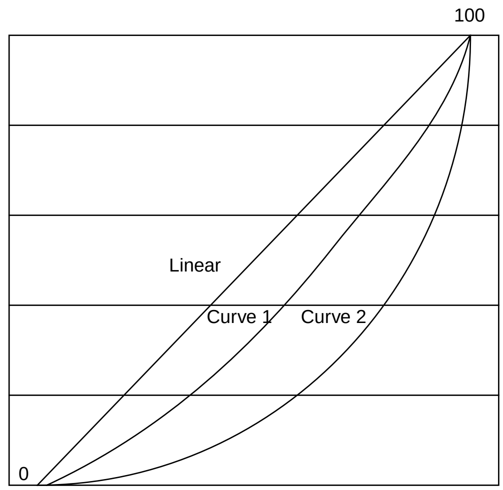
AIM Fail Output (68)

This parameter is valid for the MLS controller only. It designates a digital output for the MLS-AIM failure alarm. Setting this parameter to 0 disables it.

- Range: 0 to 34. (Setting this parameter to 0 disables the AIM fail output.)
- Default: 0 (AIM fail output is disabled).

Output Linearity Curve (69)

This parameter lets users set heat and cool outputs to one of two nonlinear output curves, or to Linear (no curve).



- Range: Users can select 0 for no curve (linear), 1 for a slight curve, and 2 for a more pronounced curve.
- Default: 0 (no curve).

SDAC Mode (70)

This parameter toggles the SDAC between current and voltage output.

- Range: 0 to 1, where 0 = voltage and 1 = current.
- Default: 0.

SDAC Low Value (71)

This parameter sets a low range value for the output device. This value must be less than the SDAC high value.

- Range: 0 to 999 for voltage outputs and 0 to 1999 for milliamp outputs.
- Default: 000 (0.00 volts) or 400 (4.00 mA).

SDAC High Value (72)

This parameter sets a high range value for the output device. This value must be greater than the SDAC low value.

- Range: 1 to 1000 for voltage outputs and 1 to 2000 for current outputs. (The controller displays this value with a fixed decimal place, so the user sees a range of 1 to 10.00 for voltage inputs and 1 to 20.00 for current outputs.)

- Default: 1000 (10.00 volts) or 2000 (20.00 mA).

Save Setup to Job (73)

This parameter saves the current setup to one of eight jobs. It is used as a command; it is not used as data. When this parameter is set to a non–zero value, the current job is saved to that job number. The parameter is then immediately reset to zero. The job is only saved once, when the controller receives this command. To resave the job, resend the command.

- Range: 1 to 8.
- Default: 0 (no job).

Input Filter (74)

The adjustable input filter dampens the analog input response.

- Range: 0 to 255 scans. (Setting the number of scans to 0 disables the filter.)
- Default: 16CLS and 8CLS = 3 Scans (both are equal to 1 second), 4CLS measurement = 6 Ambient = 0.

Loop Alarm Delay (75)

Delays process and failed sensor alarms for a loop until the alarm condition has been continuously present for longer than the specified alarm delay time.

- Range: 0 to 255.
- Default: 0 seconds (no loop alarm delay).

NOTE

MLS EPROMS prior to Version 2.30 do not support the loop alarm delay.

Loop Names (77)

This parameter assigns a two-character name to each loop for CLS, CLS2001, MLS and MLS300 controllers. For CAS and CLS200 see Channel Name (78).

- Range: 0 to 9, A to Z, °, /, %.
- Default: The loop's number.

T/C Failure Detection Flags (78)

This parameter determines the thermocouple failure detection scheme for each loop in CLS, CLS2001, MLS and MLS300 controllers. The following bits enable (bit set) or disable (bit cleared) the action.

Bit	Bit set to 0	Bit set to 1
0	Reversed thermocouple detection disabled.	Reversed thermocouple detection enabled.
1	Heat thermocouple break output averaging disabled.	Heat thermocouple break output averaging enabled.
2	Cool thermocouple break output averaging disabled.	Cool thermocouple break output averaging enabled.
3 to 7	Reserved	

- Default: all bits cleared (i.e. all disabled).

Channel Name (78)

This parameter assigns an eight-character name to each channel in the CAS and CAS200. For the CLS, CLS200, MLS and MLS300, see Loop Names (77).

Restore PID Digital Input (79)

This parameter specifies the digital input to restore the PID control from MAN mode to AUTO mode for each loop. When a thermocouple break occurs and the loop is in AUTO mode, the controller sets the loop to MAN mode. If the digital input is other than 0 and the input is low, the loop goes back to AUTO mode when the thermocouple-break condition clears.

- Range: 0 (none) to 8.
- Default: 0 (none).

Manufacturing Test (80)

This parameter is used for manufacturing to perform specific tests on each bit.

Bit	Bit set to 0	Bit set to 1
0	Watchdog timer test disabled.	Watchdog timer test enabled.
1	Halt mux scanning for calibration test disabled.	Halt mux scanning for calibration test enabled.
2 to 15	Reserved	

WARNING

This command should only be used when it is necessary to perform the above tests. Use of this command in normal operation can result in loss of data.

PV Retransmit Primary Loop Number (81)

This parameter specifies the primary loop number for obtaining the process variable (PV) from the current loop or another loop. Setting this to 0 disables PV retransmit for the loop.

- Range: 0 (none) to MAX_CH.
- Default: 0 (none).

PV Retransmit Maximum Input (82)

This parameter specifies the maximum Process Variable input allowed for PV retransmit calculation. This value must not be lower than the minimum input (command 84).

- Range: –999 to 9999 (depending on precision in primary loop).
- Default: 14000 (1400°F) for a J-type thermocouple.

PV Retransmit Maximum Output (83)

This parameter specifies the maximum output (%) allowed for Procedss Variable retransmit calculation. Once specified, the output will not exceed this percentage. This number must not be lower than the minimum output (command 85).

- Range: 0 to 100.
- Default: 100%.

PV Retransmit Minimum Input (84)

This parameter specifies the minimum PV input allowed for PV retransmit calculation. This number must not be higher than the maximum input (command 82).

- Range: –999 to 9999 (depending on precision in primary loop).
- Default: –3500 (-350°F) for J-type thermocouple.

PV Retransmit Minimum Output (85)

This parameter specifies the minimum output (%) allowed for PV retransmit calculation. Once set, the output will not drop below this percentage. This number must not be higher than the maximum output (command 83).

- Range: 0 to 100.
- Default: 0%.

Cascade Primary Loop Number (86)

This parameter specifies the cascade primary loop number to obtain the output values. This number cannot be the same as the current loop. Setting this to 0 disables the cascade feature for this loop.

- Range: 0 (none) to MAX_CH.
- Default: 0 (none).

Cascade Base Setpoint (87)

This parameter specifies the setpoint used as an offset for each loop.

- Range: –999 to 9999 (depending on the precision in the primary loop).
- Default: 250 (25°F) for a J-type thermocouple.

Cascade Minimum Setpoint (88)

This parameter specifies the minimum allowable setpoint in the cascade calculation. The resulting setpoint will not go lower than this. This number must not be higher than the maximum setpoint (command 89).

- Range: –999 to 9999 (depending on the precision in the primary loop).
- Default: 250 (25°F) for a J-type thermocouple.

Cascade Maximum Setpoint (89)

This parameter specifies the maximum allowable setpoint in the cascade calculation. The resulting setpoint will not go higher than this. This number must not be lower than the minimum setpoint (command 88).

- Range: –999 to 9999 (depending on the precision in the primary loop).
- Default: 250 (25°F) for a J-type thermocouple.

Cascade Heat/Cool Span (90)

This parameter is multiplied by the heat and cool outputs of the primary loop in the cascade calculation.

- Range: –9999 to 9999.
- Default: 0.

Ratio Control Master Loop Number (91)

This parameter specifies the ratio control master loop number to obtain the process variable. This number cannot be the same as the current loop. Setting this to 0 disables the ratio control feature for this loop.

- Range: 0 (none) to MAX_CH.
- Default: 0 (none).

Ratio Control Minimum Setpoint (92)

This parameter specifies the minimum allowable setpoint in the ratio control calculation. The resulting setpoint will not go lower than this. This number must not be higher than the maximum setpoint (command 89).

- Range: –999 to 9999 (depending on the precision in the master loop).
- Default: 250 (25°F) for a J-type thermocouple.

Ratio Control Maximum Setpoint (93)

This parameter specifies the maximum allowable setpoint in the ratio control calculation. The resulting setpoint will not go higher than this. This number must not be lower than the minimum setpoint (command 88).

- Range: –999 to 9999 (depending on the precision in the master loop).
- Default: 250 (25°F) for a J-type thermocouple.

Ratio Control Control Ratio (94)

This parameter is multiplied by the master loop process variable in the ratio control calculation. These values are multiplied by 10 to retain 0.1 ratio precision.

- Range: 1 to 9999 (control ratio 0.1 to 999.9).
- Default: 10 (control ratio 1.0).

Ratio Control Setpoint Differential (95)

This parameter specifies the setpoint used as an offset for each loop.

- Range: –999 to 9999 (depending on the precision in the master loop).
- Default: 0.

Loop Status (96)

This parameter specifies a character status indicating if the loop is in manual or automatic mode. Autotuning and ramp-soak status are also included. The characters are identical to that shown on the controller's bar display. This is an expansion of commands 4 and 46.

- Range: 'A' to 'Z' (uppercase letters), status are currently defined as:

  65 = A = Automatic

  77 = M = Manual

  84 = T = Tuning

  83 = S = Ramp/Soak Ready state (Start)

  82 = R = Ramp/Soak Running

  72 = H = Ramp/Soak Holding

  87 = W = Ramp/Soak trigger Wait state

  79 = O = Ramp/Soak Out of Tolerance
- Default: 77 (Manual).

Output Type/Disable (97)

This parameter specifies the output type (if not disabled) for the heat and cool outputs. Setting this to 255 indicates the output is disabled. Any other value indicates an enabled output. This is an expansion of command 4.

- Range: 0 to 255, output types are currently defined as:

  0 = Time Proportioning

  1 = DZC

  2 = Reserved

  3 = On/Off

  4 = SDAC

  5 = 3P DZC

  255 = Disabled
- Default:0 for heat outputs, 255 for cool outputs.

Output Reverse/Direct (98)

This parameter specifies the heat and cool output control action as either Reverse or Direct. This is an expansion of command 4.

- Range: 0 or 1.

0 = Reverse

1 = Direct

- Default: 0 for heat outputs, 1 for cool outputs.

Controller Type (99)

This parameter specifies the controller type. This is an expansion of command 30.

- Range: 0 to 3.

  0 = Controller has 4 loops

  1 = Controller has 8 loops

  2 = Controller has 16 loops

  3 = Controller has 32 loops

Ramp/Soak Profile Number (100)

This parameter specifies the assigned profile number for each loop. Setting this to 255 indicates no profile is assigned for that loop. This is an expansion of command 46.

- Range: 0 to 255.
- Default: 255 (no profile assigned).

Reference letters are assigned as follows: 0 = A, 1 = B, 2 = C, etc.

Controller Address (101)

This parameter stores the controller's network address. Changes to this parameter are effective the next time the controller powers up.

- Range: 1 to 247.
- Default: 1.

In the Anafaze/AB protocol, the controller responds to the address stored in this parameter plus 7. For example, if this parameter is set to 1 in a controller, that controller responds to messages with a DST byte value of 8 (1 plus 7).

Baud Rate (102)

This parameter stores the baud rate at which communications will operate. Changes to this parameter are effective the next time the controller powers up.

- Range: 0 to 2, with these rates available:

  0 = 9600

  1 = 2400

2 = 19200

- Default: Varies by controller.

Ready Events (103)

This parameter is accessable using the Modbus-RTU protocol only. It describes the ready segment's output states for all outputs that are not used for control or for the SDAC clock. When the loop goes to the ready state, these outputs assume the state specified by this parameter. The state of each is stored in its own register.

- Range: 0 (off) or 1 (on).
- Default: 0 (off).

Appendix A: Communications Driver

Compiling and Linking

The driver is compiled and linked with any Microsoft™ compiler version 5.1 or later. This code is probably compatible with many other C compilers, but it has not been tested as such.

Include the file “def.h” in any module that contains calls to the driver. Calls are explained in the Commands section below. A sample program and makefile have been included as a guide to using the communications driver.

Compatibility

The Anafaze Communications Driver is compatible with the CLS and MLS family of controllers. If you have a custom controller with custom data table values, you can change or add entries in the Set_Comm_Params() routine in “cmmd.c” to reflect the correct values.

Commands

The driver package consists of four commands:

- Init_Comm_Port()
- Close_Comm_Port()
- UpLoad()
- DownLoad()

This appendix covers only the usage of these commands. Setting up data, an interpreting status byte, etc., is covered in the Anafaze/AB Protocol chapter in this manual.

Init_Comm_Port()

Use Init_Comm_Port to open and initialize the comm port that is desired for communications.

BOOLEAN Init_Comm_Port(unsigned int com_port, BOOLEAN hi_baud, char error_check);

unsigned int com_port; This is either COM1 = 0, or COM2 = 1.

BOOLEAN hi_baud;	Set TRUE for 9600 baud, or FALSE for 2400 baud.

char error_check; Set to BCC, or CRC. BCC = 1. CRC = 2;

Example Call:

Init_Comm_Port(1, TRUE, BCC); Open COM2 for 9600 baud using Block Check Character(BCC).

Includes:

#include “def.h”

Return Values:

Returns TRUE if opening comm port was successful, or FALSE if attempt failed.

Close_Comm_Port()

Use this command to Release the comm port and interrupt associated with it.

void Close_Comm_Port(unsigned port);

unsigned port; This is either 0 or 1, depending on which port is open.

Example Call:

Close_Comm_Port(1); Closes comm port 2 if open.

Includes:

#include “def.h”

DownLoad()

Use this command to download controller values.

char UpLoad(int ctlr_type, unsigned char ctlr_addr, unsigned char cmmd_num, int offset, int num_elements, void * write_addr, char sts);

int ctlr_type;	TYPE_MLS16, TYPE_MLS32, TYPE_CLS4, TYPE_CLS8, TYPE_CLS16.
unsigned char ctlr_addr;	Controller address 0 to 31.
unsigned char cmmd_num;	Command or parameter number. See “def.h” for command defines.
int offset;	Offset into array.
int num_elements;	Number of array elements to download.
void * write_addr;	Starting address of data array.

char sts;	Controller status. See the Anafaze *Controller/Host InterfaceData and Communication Specification* manual.

Example Call:

return_value = DownLoad(TYPE_CLS8, 1, SETPT, 0, 8, sp); This call downloads 8 setpoints to an 8CLS with an address of 2.

Includes:

#include “def.h”

Return Value:

Returns:	1 if the download was successful. This what you should normally get.
	2 if the controller found an error in the download comm string. Sent NAK or negative acknowledge.
	3 if the download was completely unsuccessful.
	4 if the download was not completed because controller editing was in progress. Controller locked out any attempts to write.

UpLoad()

Use this command to upload controller values.

char UpLoad(int ctlr_type, unsigned char ctlr_addr, unsigned char cmmd_num, int offset, int num_elements, void * write_addr, char sts)

int ctlr_type;	TYPE_MLS16, TYPE_MLS32, TYPE_CLS4, TYPE_CLS8, TYPE_CLS16.
unsigned char ctlr_addr;	Controller address 0 to 31.
unsigned char cmmd_num;	Command or parameter number. See “def.h” for command defines.
int offset;	Offset into array.
int num_elements;	Number of array elements to download.
void * write_addr;	Starting address of data array.
char sts;	Controller status. See the *Anafaze Controller/Host InterfaceData and Communications Specification* manual.

Example Call:

return_value = DownLoad(TYPE_CLS8, 1, SETPT, 0, 8, sp); This call Uploads 8 setpoints from an 8CLS with an address of 2.

Includes:

#include “def.h”

Return Value:

Returns:	1 if the upload was successful. This what you should normally get.
	2 if the controller found an error in the upload comm string. Sent NAK or negative acknowledge.
	3 if the upload was completely unsuccessful.

Glossary

ACK	(Acknowledge) A control code that signals that a syntactically correct message packet has been received.
Address	See **Data table address** and **Device address**.
AIM	An analog input module for MLS controllers. Watlow Anafaze offers two different modules: AIM-16 and AIM-32.
ASCII	American Standard Code for Information Interchange. A code that assigns numeric values to characters.
Baud rate	The rate at which data is transmitted over a line, measured in bits per second.
BCC	Block Check Character. A method of error checking for packets.
Binary numbers	Numbers in base 2, where each digit has one or two distinct values (0 or 1).
Bit	An abbreviation for binary digit. (A binary digit can have one of two distinct values, 0 or 1). A group of four bits makes up a nibble. A group of eight bits makes up a byte.
Burst error	An erroneous series of 1’s or 0’s in the communications bit stream.
Byte	A group of eight bits.
Cleared, bit	When a bit is “cleared,” it is set to False or 0. When a bit is “set,” it is set to True or 1.
CLS	Compact Loop System. A Watlow Anafaze PID controller with 4, 8 or 16 loops.
CRC	Cyclic Redundancy Check. A method of error checking for packets.
Data table address	The logical address where data is located.

Deadband, alarm	The range through which a process variable must travel from the alarm setpoint toward the process setpoint before an alarm clears.
Derivative control action	A control action in which the output value is proportional to the rate of change of the error between the process variable and setpoint.
Deviation alarm	The deviation alarm value is an absolute value that is always relative to the setpoint. The process is in Alarm in the following cases: Above (setpoint + deviation value) Below (setpoint – deviation value)
Device address	The communications address assigned to the controller or host software.
DLE	Data Line Escape. An escape code that signals that a control code follows it.
Double-bit error	An error in which two bits in a packet are incorrect.
Duplex, full	Communications in which each node can simultaneously transmit and receive.
ENQ	Enquiry. A control code that the software sends to the controller, asking it to resend the last ACK or NAK.
ETX	End Text. A control code that signals the end of a transmission.
Gain	The parameter that users can alter through host software to set the proportional control action. The gain is a unitless number that is inversely proportional to the proportional band. (See also **Proportional Band**)
Hexadecimal numbers	Numbers in base 16 where each digit has one of 16 possible values (0 to F).
Integral control action	Control action in which the output is proportional to the time integral of the difference between the setpoint and process variable. (In other words, the rate of change of the output is proportional to the input.)
Job	A set of operating conditions (setpoints, alarms, PID constants, etc.).
Linear input	Watlow Anafaze controllers have an optional linear input type that allows you to scale raw input readings to the engineering units of your process.

LSB	Least Significant Byte. For all two-byte data types, the LSB is transmitted before the MSB (Most Significant Byte) in the packet.
MLS	Modular Loop System. A Watlow Anafaze controller.
MSB	Most Significant Byte. For all two-byte data types, the MSB is transmitted after the LSB (Less Significant Byte) in the packet.
NAK	Not Acknowledged. A control code that signals that a syntactically incorrect message packet has been received.
Nibble	A group of four bits or half a byte.
Packet	A packet consists of a sequence of bytes in a specific format; it can be as large as 256 bytes of data. Information is exchanged between host software and the controller in packets.
Parity	Error detection coding for serial communications. MLS, CLS and IRC2 controllers use no parity.
Precision parameter	Indicates the decimal format for controller parameters such as process variable, setpoint, etc.
Proportional Band (PB)	The parameter that users alter from the front panel to set the proportional control action, expressed in engineering units of the process variable.
Proportional control action	Control action with a continuous, linear relationship between the output value and the difference between the setpoint and the process variable.
Protocol	A set of rules for the timing and format of messages in the network.
Pulse input	An input for CLS controllers that measures a digital pulse signal.
Recipe	See **Job**.
SDAC	Serial Digital Analog Converter. A high-precision digital-to-analog converter for control outputs.
Serial communications	Communications between a computer and another device (controller, for example). Watlow Anafaze hardware supports two formats: RS-232 for single device at short distances, and RS-485 for multiple devices at longer distances.

Set, bit	See **Cleared, bit**.
Single-bit error	An error in which only one bit is incorrect.
Stop bit	The last part of a character that assures that the next start element is recognized.
STX	Start Text. A control code that signals the beginning of a transmission.
TI	Time of Integral, or Reset. The parameter that users alter to set the integral control action, expressed in seconds per repeat.
TD	Derivative term, or Rate. The parameter that users alter to set the derivative control action, expressed in seconds.